ID 88054830

1792
Geo
BuFi

PROJECT: FIELD ECOLOGY TECHNICAL REPORT ON THE COSO GEOTHERMAL STUDY AREA

IN SUPPORT OF: COSO GEOTHERMAL DEVELOPMENT ENVIRONMENTAL STATEMENT

U.S. Department of the Interior
Bureau of Land Management
Bakersfield District Office
800 Truxtun Avenue, Room 311
Bakersfield, CA 93301

Rockwell International

Environmental Monitoring & Services Center
Environmental & Energy Systems Division
2421 West Hillcrest Drive
Newbury Park, CA 91320
(805) 498-6771

April 1980

Contract No. YA-512-CT8-216

88054830

BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047

PROJECT: FIELD ECOLOGY TECHNICAL REPORT ON THE COSO GEOTHERMAL STUDY AREA

IN SUPPORT OF: COSO GEOTHERMAL DEVELOPMENT ENVIRONMENTAL STATEMENT

U.S. Department of the Interior
Bureau of Land Management
Bakersfield District Office
800 Truxtun Avenue, Room 311
Bakersfield, CA 93301

Rockwell International

Environmental Monitoring & Services Center
Environmental & Energy Systems Division
2421 West Hillcrest Drive
Newbury Park, CA 91320
(805) 498-6771

April 1980

Contract No. YA-512-CT8-216

ACKNOWLEDGMENTS

This report was prepared by Environmental Resources Group (ERG) of Los Angeles. Major participants in the project were:

Project Management	Louise W. Hall
Field Ecology Team Leader	C. Robert Feldmeth
Aquatic Habitats	C. Robert Feldmeth, Principal Investigator; David Soltz
Amphibians and Reptiles	Timothy Brown, Joseph Gorman
Avifauna	Daniel A. Guthrie, Principal Investigator
Small Mammals and Carnivores	Philip Leitner, Principal Investigator; Patricia Brown
Large Mammals (Feral Burros)	Susan Woodward, Principal Investigator; Jerry McDonald
Botany	James S. Henrickson, Principal Investigator; Richard Minnich

Throughout the project, many organizations and individuals have cooperated generously. Among those who made significant contributions are the following, to whom we wish to express our appreciation:

Philip and Betty Hennis, Rose Valley Ranch, Olancha

Philip Pister, California State Department of Fish and Game, Bishop

Robert Thorne, Rancho Santa Ana Botanic Garden, Claremont

David White, University of Utah, Raft River Test Site

Les Saxton, T. C. Barling, and Carolyn Shepherd, US Naval Weapons Center, China Lake

Richard Bate, Past President, Little Lake Hunt Club, Little Lake and Van Nuys

ACKNOWLEDGMENTS

This report was prepared by [illegible] Research [illegible] of the [illegible]. Major [illegible] to the [illegible] were:

Project Management	[illegible] R. [illegible]
Field Geology Team Leader	G. [illegible]
Fossil [illegible]	C. [illegible]
Amphibians and Reptiles	[illegible]
Molluscs	Daniel R. [illegible]
Small Mammals and Carnivores	[illegible]
Large Mammals (Feral Burros)	[illegible]
Botany	[illegible]

Throughout the project, many organizations and individuals were [illegible] generously. [illegible] are the following, to whom we wish to express our appreciation:

[illegible]

[illegible], California State [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

CONTENTS

Report No.		
I	Aquatic Habitats	(21 pages)
II	Amphibians and Reptiles	(13 pages)
III	Avifauna	(42 pages)
IV	Small Mammals and Carnivores	(65 pages)
V	Large Mammals	(32 pages)
VI	Botany	(97 pages)

REPORT I

AQUATIC HABITATS OF THE
COSO GEOTHERMAL STUDY AREA

Prepared by
C. Robert Feldmeth and David Soltz

July 1979

TABLE OF CONTENTS

Page

Introduction I-1

Methods I-3

Results and Discussion I-4

Haiwee Spring I-4

Little Lake I-6

Sierra Streams I-15

Summary I-19

References I-21

TABLES

I. Water Chemistry of Haiwee Spring I-5

II. Aquatic Invertebrate Species of Haiwee Spring I-7

III. Water Chemistry of Little Lake I-11

IV. Water Chemistry of Wells at North End of Little Lake I-13

V. Little Lake Zooplankton I-14

VI. Water Chemistry of Little Lake Canyon Creek I-16

VII. Water Chemistry of Five Mile Canyon Creek I-17

VIII. Water Chemistry of Spring Near Lewis Ranch I-18

IX. Water Chemistry of Spring in Portuguese Canyon I-18

X. Aquatic Invertebrates in Tunawee Canyon Stream I-20

FIGURES

1. Aquatic Habitats of the CGSA and Vicinity I-2

2. Little Lake: Depth Contours I-9

INTRODUCTION

There are three basic aquatic environments present in the Coso area (see Figure 1). Haiwee Spring represents an isolated desert stream-oasis, which flows at the surface for about 200 m in a small canyon approximately 8 km north of Coso Hot Springs and just east of the Coso Geothermal Study Area (CGSA). All life forms in this spring had to cross a barrier of desert, and hence the ecosystem present here is a relatively simple one. Little Lake, the second habitat type, is a small lake located just south and west of the CGSA in the lower portion of Rose Valley. Little Lake is very shallow, is subject to high water temperatures in summer, and experiences abundant mixing by winds which often sweep through the area. The third habitat type is represented by small streams which flow from the Sierra and approach the western boundary of the CGSA. These are quite similar in nature to Haiwee Spring but are more open to colonization by aquatic invertebrates from the numerous aquatic systems of the Sierra Nevada range.

All three environment types lie just outside the CGSA (though a few Sierran streams occasionally dissipate just within its boundaries). However all are important habitats, not only for aquatic species but also for terrestrial forms and avifauna (see other Technical Reports in this volume) and all are close enough to the CGSA to warrant inspection. Within the boundaries of the study area proper, the only water sources are stock ponds, alfalfa irrigation, ephemeral ponds after rains, and Coso Hot Springs. None of these areas has a well-developed aquatic ecosystem.

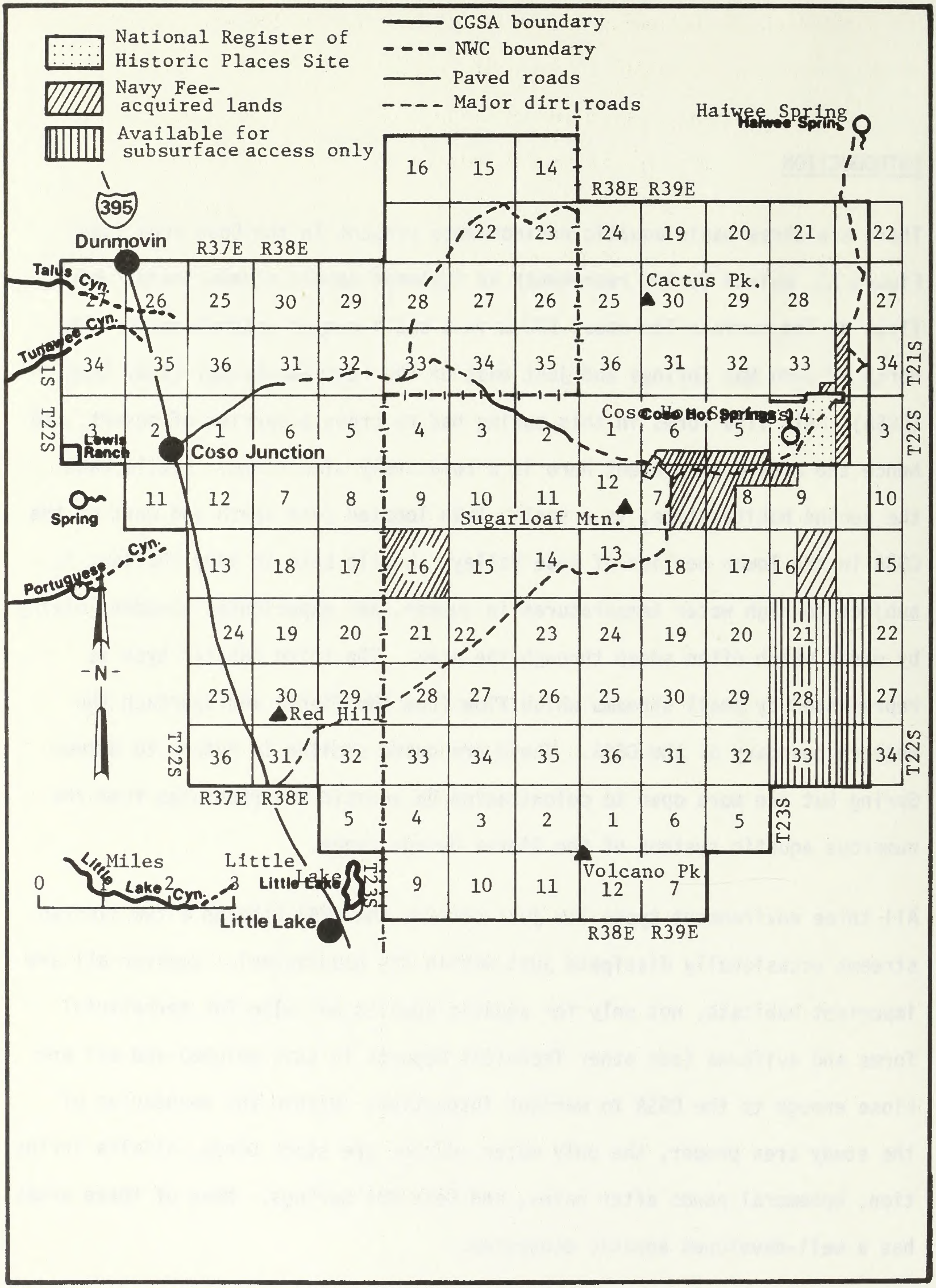


Figure 1. AQUATIC HABITATS OF THE CGSA AND VICINITY

The purpose of the following report is to characterize the environment of each of the three aquatic habitats identified above. The physical, chemical and biological components of each are described. Also, most measurements and analyses were designed to aid in determining the impact upon these systems which would result from utilization of water resources of this desert area for geothermal electrical power generation.

Geothermal development may or may not result in a lowering of the water levels. Since there is some possibility of this occurring, the aquatic habitats (Little Lake, Haiwee Spring and others on the margins of the CGSA) were studied for baseline conditions. Such data will allow for impact assessment if biological data suggest a potential for lowering of water levels and for monitoring if the Coso KGRA is developed.

METHODS

Physical measurements such as temperature and light were made directly using standard procedures (Yellow Springs Instruments telethermometer, CdS standard light meter). Depth profiles in Little Lake were determined using a sounding weight and metered line.

Dissolved oxygen was measured with a southern Analytical dropping mercury electrode and pH with a Beckman portable meter. Water samples were collected from each area and analyzed by Babcock Labs (Riverside, California) for the following constituents: total hardness ($CaCO_3$), calcium, magnesium, sodium, potassium, total alkalinity ($CaCO_3$), hydroxide, carbonate, bicarbonate, sulfate, chloride, nitrate, electrical conductivity, boron, fluoride, pH and total dissolved residue. Aquatic invertebrates were captured with dipnets, and benthic forms were sampled with an Ekman grab (15 x 15 cm). Zooplankton were collected with a general tow (25 cm diameter net, mesh No. 25 bolting silk) and quantitative determinations were made by collecting water with a 1.8 liter non-metallic Kemmerer bottle and passing the sample through a small plankton net (mesh No. 25 bolting silk). Fish were sampled using either dip nets or experimental mesh gill nets provided by the Bishop office of the California Department of Fish and Game.

RESULTS AND DISCUSSION

HAIWEE SPRING

Haiwee Spring is located in a small canyon 8 km north of Coso Hot Springs where water comes to the surface along a canyon floor for a distance of about 200 m. The stream consists of a series of pools with some connecting portions exhibiting flowing water. The entire length of the stream is shaded by a dense stand of arroyo willow (*Salix laevigata*).

The water temperature was equal to ambient air and the spring contained a diverse complement of aquatic organisms when visited in October of 1978 and March of 1979. The aquatic flowering plant, water cress (*Nasturtium officinale*) was abundant in shallow marshy and flowing portions of the stream while *Spirogyra* sp. and *Nostoc* sp. were common algal species present in pools and slower flowing portions. Water chemistry analyses are presented in Table 1.

Most of the pools are shaded and hence the primary productivity by aquatic plants is probably relatively unimportant during the warmer spring, summer and fall periods. A considerable amount of the organic input into the spring is

Table I. WATER CHEMISTRY OF HAIWEE SPRING*

Total hardness as $CaCO_3$ = 152 mg/l

Calcium (Ca)	38 mg/l	1.92 me/l
Magnesium (Mg)	13 mg/l	1.12 me/l
Sodium (Na)	29 mg/l	1.26 me/l
Potassium (K)	6 mg/l	0.15 me/l
Ammonium (NH_4)	0.2 mg/l	0.01 me/l
TOTAL cations		4.46 me/l

Total alkalinity as $CaCO_3$ = 128 mg/l

Hydroxide (OH)	0	
Carbonate (CO_3)	6 mg/l	0.20 me/l
Bicarbonate (HCO_3)	143 mg/l	2.35 me/l
Sulfate (SO_4)	73 mg/l	1.52 me/l
Chloride (Cl)	16 mg/l	0.45 me/l
Nitrate (NO_3)	1 mg/l	0.02 me/l
TOTAL anions		4.54 me/l

Electrical conductivity
($EC \times 10^6$ @ 25°C) = 430 umho/cm^3

pH = 8.2

Total dissolved residue @ 180°C = 285 mg/l

Boron (B) 0.0

Fluoride (F) 0.4

*Analysis by Babcock Labs, Riverside, California, April, 1979.

probably due to autumn leaf-fall from the deciduous willows. Once in the water the leaves are soon covered with a bacterial film and then utilized as a food source by herbivorous aquatic insects and invertebrates.

Aquatic insects are numerous and indicate that a permanent aquatic ecosystem has developed. The pool surfaces are inhabited by a large number of water striders (Gerris notabilis). Several species of diving beetles of the families Dytiscidae and Hydrophilidae are also present. The predaceous diving bug Notonecta shooterii (backswimmer) was also present as were mayflies, amphipods, dragonflies and damselflies. Where the water flowed between pools, dense aggregations of blackfly larvae (Simulium bivattatum) were found. The presence of this rheophilic species plus the numerous other insect groups indicated that a very typical foothill-type stream community is present. The species list for Haiwee Spring is presented in Table II.

Haiwee Spring is subject to wide annual and seasonal variations in surface flow. However, it is believed Haiwee Spring derives water from runoff in the Coso Range and would probably not be affected by any geothermal development.

LITTLE LAKE

Little Lake is a small shallow body of water approximately one mile (1.6 km) in length which occupies a Pleistocene river channel bounded on each side by volcanic lava flows. The water is quite shallow; maximum depth is only 5 feet (see Figure 2) and the lake is probably of recent origin. A photograph obtained from Mr. Richard Bate, past president of the Little Lake Hunt Club (present lessee of the northern portion of the lake), clearly indicates that in 1909 the area which is now Little Lake was a marsh occupied mainly by short sedges and grasses with tules around areas that appear to be small channels.

Table II. AQUATIC INVERTEBRATE SPECIES OF HAIWEE SPRING

	Species	Frequency
Class Crustacea		
Order Amphipoda		
	Hyalella azteca	common
Class Insecta		
Order Ephemeroptera		
Family Baetidae		
	Baetodes sp.*	common
Order Odonata		
Suborder Zygoptera		
Family Coenagrionidae		
	Ischnura sp.*	common
Suborder Anisoptera		
Family Gomphidae		
	Gomphus sp.*	common
Order Hemiptera		
Family Gerridae		
	Gerris notabilis	common
Family Notonectidae		
	Notonecta shooterii	common
Order Coleoptera		
Family Dytiscidae		
	Hydrovatus confertus	common
	Thermonectus basillaris	rare
Family Hydrophilidae		
	Species undetermined*	rare

Table II. (continued)

	Species	Frequency
Order Trichoptera		
Family Limnephilidae		
	2 undetermined species*	common
Family Leptocellidae		
	Leptocella albida	rare

*Nymphs or larvae were too immature to identify further than Family.

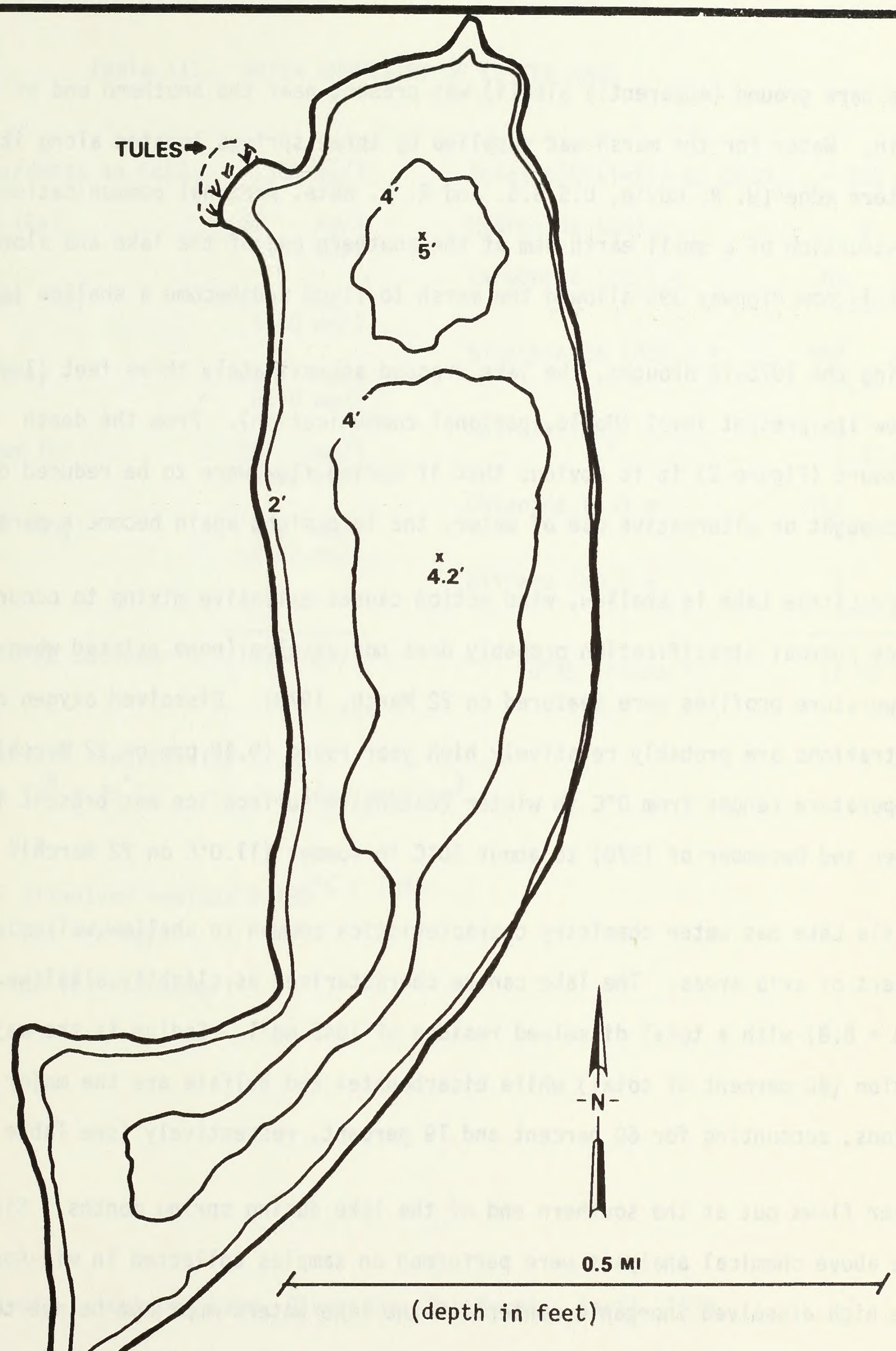


Figure 2. LITTLE LAKE: DEPTH CONTOURS

Some bare ground (apparently alkali) was present near the southern end of the basin. Water for the marsh was supplied by three springs located along its western edge (W. R. Moyle, U.S.G.S. and R. L. Bate, personal communication). Construction of a small earth dam at the southern end of the lake and along what is now Highway 395 allowed the marsh to flood and become a shallow lake.

During the 1975-76 drought, the lake dropped approximately three feet (1 m) below its present level (Moyle, personal communication). From the depth contours (Figure 2) it is obvious that if spring flow were to be reduced due to drought or alternative use of water, the lake might again become a marsh.

Since Little Lake is shallow, wind action causes extensive mixing to occur. Hence thermal stratification probably does not develop (none existed when temperature profiles were measured on 22 March, 1979). Dissolved oxygen concentrations are probably relatively high year round (9.40 ppm on 22 March) while temperature ranges from 0°C in winter (extensive surface ice was present in November and December of 1978) to about 30°C in summer (11.0°C on 22 March).

Little Lake has water chemistry characteristics common to shallow well-mixed waters of arid areas. The lake can be characterized as slightly alkaline (pH = 8.8) with a total dissolved residue of 1045 mg/l. Sodium is the major cation (60 percent of total) while bicarbonates and sulfate are the major anions, accounting for 60 percent and 19 percent, respectively (see Table III).

Water flows out at the southern end of the lake during spring months. Since the above chemical analyses were performed on samples collected in mid-April, the high dissolved inorganic content of the lake waters must not be due to

Table III. WATER CHEMISTRY OF LITTLE LAKE

Total hardness as $CaCO_3$	= 380 mg/l	
Calcium (Ca)	52 mg/l	2.60 me/l
Magnesium (Mg)	60 mg/l	5.00 me/l
Sodium (Na)	200 mg/l	8.70 me/l
Potassium (K)	24 mg/l	0.62 me/l
Ammonium (NH_4)	0.4 mg/l	0.02 me/l
TOTAL cations=		16.94 me/l

Total alkalinity as $CaCO_3$	= 523 mg/l	
Hydroxide (OH) =	0	
Carbonate (CO_3) =	69 mg/l	2.30 me/l
Bicarbonate (HCO_3) =	497 mg/l	8.15 me/l
Sulfate (SO_4) =	158 mg/l	3.29 me/l
Chloride (C l) =	112 mg/l	3.15 me/l
Nitrate (NO_3) =	2 mg/l	0.03 me/l
TOTAL anions =		16.92 me/l

Electrical conductivity
(EC x 10^6 @ 25°C) = 1600 umho/cm^3

pH = 8.8

Total dissolved residue @ 180°C = 1045

Boron (B) = 6 mg/l

Fluoride (F) = 1.4 mg/l

*Analysis by Babcock Labs, Riverside, California, April, 1979.

concentrating effects of evaporation alone. The inflow springs are presently submerged several feet below the lake surface and hence collection and analysis of these waters was not possible. However, two shallow wells present at the north end of the lake contain water which is probably similar to that of the springs which feed the lake (R. Weiss, personal communication). Analyses of these wells (Moyle, 1977) indicate high levels of sodium, bicarbonate and sulfate with a total dissolved residue of 700 mg/l (see Table IV).

Biologically, Little Lake is very productive. The water is a brown-green color indicating that a dense population of phytoplankton is present. Quantitative determinations of zooplankton standing crops indicated a population of over 800,000 individuals per m^3 (see Table V). The presence of abundant inorganic ions and the emergent vegetation (tules, sedges and grasses) around the lake, as well as heavy use by migrant water fowl, make nutrient conditions ideal for planktonic species. Warm summer temperatures, adequate mixing and abundant dissolved oxygen also contribute to conditions which make productivity high.

The lake bottom is covered by a mat of detritus (decomposing plant material). Large numbers of damselflies, amphipods and mayflies are present on top of this vegetational mat. Beneath the mat is a fine, silty substrate supporting very little benthic fauna. Ekman grabs indicated that almost all benthic invertebrates occurred on or in the detrital mat with the exception of a large red chironomid larva which apprently thrives in the fine mud beneath.

Mosquito fish (Gambusia affinis) are abundant around the lake margin in shallow water and these small fish were captured using a dip net. Larger fishes were

Table IV. WATER CHEMISTRY OF WELLS AT NORTH END OF LITTLE LAKE*

	mg/l
Magnesium (Mg)	39
Sodium (Na)	131
Potassium (K)	13
Total alkalinity ($CaCO_3$)	423
Bicarbonate (HCO_3)	516
Carbonate (CO_3)	0
Sulfate (SO_4)	87
Chloride (Cl)	82
Fluoride (F)	0.9
Boron (B)	2.0
Nitrate (NO_3)	2.3

Total dissolved residue at 180°C = 700 mg/l

Hardness (Ca, Mg) = 330 mg/l

pH = 8.1

Specific conductance = 1070 umho/cm^3

*Data from Moyle (1977)

Table V. LITTLE LAKE ZOOPLANKTON

GENERAL TOW:

	Species	Frequency
Order Cladocera		
	Bosmina sp.	rare
	Ceriodaphnia sp.	common
Order Copepoda		
	Cyclops sp.	common
	copepod nauplius larva	common
Order Ostracoda		
	unidentified ostracod	rare

QUANTITATIVE SAMPLES: (5.4 l sample size)

Sample 1:

Species	No./l	No./m^3
Ceriodaphnia sp.	59.3	59,300
Cyclops sp.	562.9	562,900
copepod nauplius larva	162.9	162,900
ostracod	44.4	44,000

Sample 2:

Species	No./l	No./m^3
Ceriodaphnia sp.	88.8	88,000
Cyclops sp.	622.2	622,220
copepod nauplius larva	118.5	118,500

sampled with three experimental mesh gill nets set on 22 March in the south and central portions of the lake. The next morning the nets yielded 139 Sacramento perch (Archoplites interruptus) which ranged in size from 76 to 210 mm (mean = 134.5 mm). Approximately 15 fish were preserved for later analysis and the remainder were returned to the lake, live. Internal examination indicated the females had maturing eggs and all fish were fat and healthy. The stomach contents contained no plant material and indicated an apparent preference for the amphipod, Hyalella azteca. Other organisms present were damselflies, mayflies, midge larvae and ants. The relatively small size of the fish is probably due to their high population density and hence competition in a shallow, relatively homogeneous habitat.

SIERRA STREAMS

The final habitat consists of small mountain streams which flow eastward from the Sierra. At an elevation of approximately 4,000 feet, the water percolates into the alluvium and hence never enters the CGSA except during floods. Canyons with water include Talus, Tunawee, Portuguese, Little Lake and Five-Mile (the last is approximately 4 miles south of Little Lake Canyon); and springs are also present at the Lewis Ranch, just west of Coso Junction. Water chemistry analyses for these areas indicate they are relatively high in calcium and sodium as well as carbonate and bicarbonate (see Tables VI - IX).

The small stream in Tunawee Canyon was examined for aquatic invertebrates on 23 March 1979. Most of the area is so densely covered with willows that little exposed water is present. A small dam-created pond yielded the following insect

Table VI. WATER CHEMISTRY OF
LITTLE LAKE CANYON CREEK*

Total hardness as $CaCO_3$ = 196 mg/l

Calcium (Ca)	54 mg/l	2.68 me/l
Magnesium (Mg)	15 mg/l	1.24 me/l
Sodium (Na)	50 mg/l	2.17 me/l
Potassium (K)	8 mg/l	0.21 me/l
Ammonium (NH_4)	0.2 mg/l	0.01 me/l
TOTAL cations		6.31 me/l

Total alkalinity as $CACO_3$ = 163 mg/l

Hydroxide (OH)	0	
Carbonate (CO_3)	27 mg/l	0.90 me/l
Bicarbonate (HCO_3)	143 mg/l	2.35 me/l
Sulfate (SO_4)	86 mg/l	1.79 me/l
Chloride (Cl)	32 mg/l	0.90 me/l
Nitrate (NO_3)	1 mg/l	0.02 me/l
TOTAL anions		5.96 me/l

Electrical conductivity
(EC x 10^6 @ 25°C) + 590 umho/l

pH = 8.8

Total dissolved residue @ 180°C = 390 mg/l

Boron (B) = 0.1 mg/l

Fluoride (F) = 2.4 mg/l

*Analysis by Babcock Labs, Riverside, California, April, 1979

Table VII. WATER CHEMISTRY OF FIVE MILE CANYON CREEK*

Total hardness as $CaCO_3$ = 208 mg/l

Total alkalinity as $CaCO_3$ = 160 mg/l

Calcium (ca)	46 mg/l	2.31 me/l
Magnesium (mg)	22 mg/l	1.84 me/l
Sodium (Na)	75 mg/l	3.26 me/l
Potassium (K)	9 mg/l	0.23 me/l
Ammonium (NH_4)	0.1 mg/l	0.01 me/l
TOTAL cations		7.66 me/l

Hydroxide (OH)	0	
Carbonate (CO_3)	27 mg/l	
Bicarbonate (HCO_3)	140 mg/l	2.30 me/l
Sulfate (SO_4)	155 mg/l	3.23 me/l
Chloride (Cl)	36 mg/l	1.00 me/l
Nitrate (NO_3)	1 mg/l	0.02 me/l
TOTAL anions		7.45 me/l

Electrical conductivity
(EC x 10^6 umho/cm^3)

pH = 8.6

Total dissolved residue @ 180°C = 465 mg/l

Boron (B) = 0.2 mg/l

Fluoride (F) = 2.4 mg/l

*Analysis by Babcock Labs, Riverside, California, April, 1979

Table VIII. WATER CHEMISTRY OF SPRING NEAR LEWIS RANCH*

	mg/l		mg/l
Calcium (Ca)	74	carbonate and bicarbonate (CO_3 and HCO_3)	270
Magnesium (Mg)	15	sulfate (SO_4)	97
Potassium (K)	13	chloride (Cl)	32
Sodium (Na)	75	Nitrate (NO_3)	0.09
		Silica (SIO_2)	42

Electrical conductivity = 430 umho/cm^3

pH = 7.56

Total dissolved solids (sum of constituents) = 618 mg/l

Boron (B) = 0.21 mg/l

*Analysis by Amtech, San Diego, California, January, 1979

Table IX. WATER CHEMISTRY OF SPRING IN PORTUGUESE CANYON

Calcium (Ca)	57.4	Carbonate and bicarbonate (CO_3 and HCO_3)	238
Magnesium (Mg)	10.6	Sulfate (SO_4)	23.4
Potassium (K)	5.8	Chloride (Cl)	13
Sodium (Na)	18.0	Nitrate (NO_3)	.001
		Silica (SiO_2)	19

Electrical conductance = 446 umho/cm^3

pH = 8.28

Total dissolved solids (sum) = 385 mg/l

Boron (B) = 0.45

Fluoride (F) = 0.56

species: Aeschna sp. (dragonfly nymph), Coenagrionidae (damselfly nymph), Limnephilidae (caddis larva), Hydrophilidae (beetle adult) and Gyrinidae (beetle adult) (see Table X).

SUMMARY

The streams of the Sierra slope and Haiwee Spring are typical small foothill, flowing water habitats. They contain a good assemblage of aquatic invertebrates and experience large thermal cycles annually. Water chemistry indicates that mineral content is low to moderate and is probably a function of the geological structures the water passes through before reaching the surface. No rare or endangered species of aquatic plants or animals were found in these habitats, nor were any uncommon or specially significant or unique species encountered.

Little Lake is a shallow, desert lake which is fed by springs that occur along its western shore. It is inhabited by large numbers of invertebrates (amphipods and numerous species of aquatic insects) and contains two introduced fish species: Sacramento perch and mosquitofish. This habitat is an important aquatic refuge for numerous species of migratory birds; however, no rare or endangered aquatic species (and no especially uncommon species) were found to be present.

Table X. AQUATIC INVERTEBRATES IN TUNAWEE CANYON STREAM

	Species	Frequency
Class Insecta		
Order Odonata		
Suborder Anisoptera		
Family Aeschnidae	Aeschna sp.	common
Suborder Zygoptera		
Family Coenagrionidae	genus undetermined*	common
Order Coleoptera		
Family Gyrinidae	genus undetermined*	common
Family Hydrophilidae	genus undetermined*	common
Order Trichoptera		
Family Limnephilidae	genus undetermined*	common

*Nymphs or larvae were too immature to identifyfurther than Family.

REFERENCES

Moyle, W. R., 1977. "Summary of basic hydrologic data collected at Coso Hot Springs, Inyo County, California." U.S. Geological Survey. Open-File Report 77-485. 93 pp.

Needham, J. G., and P. R. Needham, 1962. A Guide to the Study of Fresh Water Biology. Holden-Day, San Francisco. 108 pp.

Usinger, R. L., 1971. Aquatic Insects of California. University of California Press. 508 pp.

Ward, H. B., and G. C. Whipple. (ed., W. T. Edmondson), 1959. Fresh-Water Biology. John Wiley and Sons, New York. 1,248 pp.

REPORT II

AMPHIBIANS AND REPTILES
OF THE
COSO GEOTHERMAL STUDY AREA

Prepared by

Timothy W. Brown, Ph.D.

August, 1979

Field Work Conducted by Joseph Gorman, Ph.D.

TABLE OF CONTENTS

	Page
Introduction	II-1
Overview of Study Area	II-1
Methodology	II-2
Results and Discussion	II-4
Freshwater Marsh: Little Lake and Haiwee Spring	II-4
Shadscale Scrub	II-8
Creosotebush Scrub	II-8
Mixed Desert Scrub	II-10
Geothermal Areas: Coso Hot Springs	II-11
Sensitive Habitats	II-11
Protected, Rare and Endangered Species	II-12
Summary	II-12
References	II-13

TABLES

Table 1. Amphibians and Reptiles of the CGSA II-5

FIGURES

Figure 1. Herpetofaunal Study Areas, CGSA II-3

INTRODUCTION

The purpose of this study was to determine what amphibian and reptile species are present in the Coso Geothermal Study Area (CGSA). Other aims were to estimate relative densities per unit area, and to assess probable presence of other amphibian and repitile species (not sighted).

OVERVIEW OF STUDY AREA

The CGSA is an area of about 113.5 square miles (294 square kilometers). The area is high desert, including both Northern Mojave Desert and Southern Great Basin characteristics. Elevations are roughly between 3200 (973 m) and nearly 6000 feet (1829 m). To the west of the CGSA is the Sierra Nevada range rising to over 9,000 feet (2,740 m), forming a rain shadow in the Coso area.

Rainfall is little and surface streams are mainly confined to the steep eastern slope of the Sierra; these streams enter the CGSA only a few months of the year. A small stream also exists north of Coso Hot Springs (Haiwee Spring) and a small body of water is present at Little Lake, south and west of the CGSA. Both of these aquatic areas are outside the CGSA but close enough to warrant study. The stream fumaroles in and near Coso Hot Springs provide insufficient water to be important to herpetofaunal habitats. Otherwise the area is arid with a mean precipitation of less than 6 inches (15 cm) annually.

The habitat preferences of repitles in the CGSA are based principally upon the following criteria: substrate, physical structure of the vegetation, elevation, and slope direction. With amphibians, the overriding need is surface water for reproduction, regardless of how well other requirements are met.

Substrate refers to the physical structure of the ground surface; in the CGSA this can range from the mud-cracked surface of alkaline playas to windblown sands or rocky cliffs. The physical structure of the vegetation refers to the height and density of plant cover rather than species composition _per se_. Shade, shelter, and available prey are far more important than are the individual plant species,[1] since all amphibians and reptiles of the CGSA except for tadpoles (amphibian larvae) and three species of lizard, are stricly carnivorous. Elevation and slope direction determine the microclimate within a habitat: south-facing slopes are warmer and drier than north-facing ones at the same elevation. This largely accounts for the mosaic of habitats scattered discontinuously over the rugged topography of the study area.

The apparent abundance of certain amphibians and reptiles and scarcity of others is largely a function of their habits. Most lizards are conspicuously active during the day and therefore are more likely to be seen by people than are snakes and amphibians, which are mostly nocturnal. Thus some rather common species are almost never found except by riding roads at night or by setting pitfall traps. Even then the locations of such traps must be carefully selected or entire populations of small secretive species may be overlooked.

---

[1] The only exceptions would be the few plant species which provide some unique physical feature such as the shelter afforded by fallen Joshua tree limbs.

Consequently, the presence of a few kinds of amphibians and reptiles in the Coso Geothermal Study Area can only be inferred based upon the presence of suitable habitat, until future work clarifies their status.

METHODOLOGY

Four principal methods were employed for sampling the amphibians and repitles: on-foot reconnaissance of six selected study sites, pitfall can trapping, on-foot and vehicular reconnaissance over the general CGSA and immediate vicinity, and inquiry of local residents, Naval Weapons Center personnel, and investigators concerned with other related studies in the Coso Geothermal Study Area.

Six sites were chosen by Dr. Joseph Gorman, in October 1978, for intensive sampling in representative habitats; see Figure 1. These were in: 1) Creosotebush Scrub on the West side of Rose Valley, 2) Creosotebush Scrub on the eastern side of Rose Valley, 3) Joshua Tree Woodland, 4) Mixed Desert Scrub, 5) riparian vegetation along the shore of Little Lake, and 6) Shadscale scrub. In addition, Coso Hot Springs and Haiwee Spring were examined but not intensively sampled. These locations corresponded generally to those selected for the bird survey by Dr. Daniel Guthrie -- see Technical Reports, Avifauna -- as well as those studied by Zembal et al. (1978). A one-hectare (100 meter x 100 meter) sampling plot was established at each site (except at Haiwee Spring and Coso Hot Springs). During periods of field work each site was visited twice a day and systematically walked along a series of generally north-south and east-west transects, each 100 meters in length. Where possible, all amphibians and reptiles observed were captured and released, or otherwise noted with binoculars for positive identification.

Also, at each of the first five sampling sites, 16 five-gallon cans were buried in a 100 meter x 100 meter grid pattern, each 25 meters from the next. A flat board was propped up with stones over the mouth of each can, thus offering enticing shelter to small reptiles and amphibians and making a very efficient pitfall trap. These were especially useful for establishing the presence of burrowing or nocturnal species not normally encountered by other methods.

Reconnaissance of localities other than these sites consisted both of daytime and nighttime road driving within the Coso Geothermal Study Area and on-foot visual surveys. In early spring, many reptiles bask on paved roads during the brief warm hours of the day; in late spring and summer the days are too hot, and amphibians and reptiles then often engage in a kind of nocturnal "basking" on blacktop roads which hold the day's heat well into the night. Consequently driving slowly along little-used paved roads at the right time can often yield observations of a number of species. Some (like leaf-nosed snakes, banded geckos, and shovel-nosed snakes) are seldom seen any other way. Habitats not crossed by roads can be only surveyed by on-foot reconnaissance. This is especially true of aquatic or very rocky sites, since pitfall traps cannot be used in these habitats.

Local inquiry can sometimes uncover very useful information, but this must be weighed judiciously for unintentional exaggeration or misinformation. Investigators do well to be conservative in accepting such information unless from trained observers.

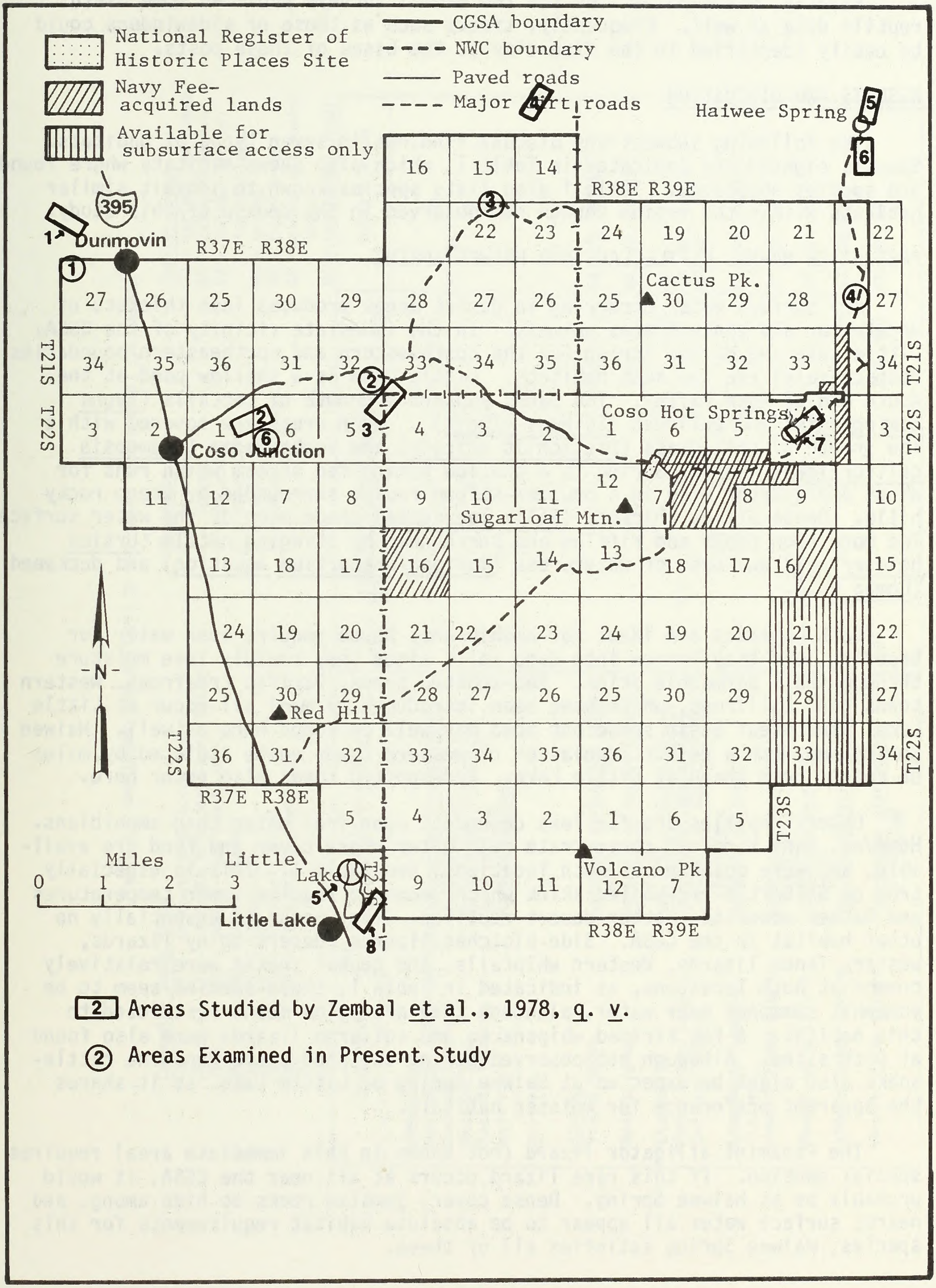


Figure 1. HERPETOFAUNAL STUDY AREAS, CGSA

Finally, scent-posts used for the mammal surveys provided some useful reptile data as well. Frequently, tracks such as those of sidewinders could be easily identified in the fire clay at the bases of these posts.

RESULTS AND DISCUSSION

The following subsections discuss findings in seven types of habitats. Species sighted are indicated in Table 1, which also shows habitats where found and species abundance. Table 1 also lists species known to inhabit similar habitats within the region though not observed in the course of this study.

FRESHWATER MARSH: LITTLE LAKE AND HAIWEE SPRING

Any surface water occurring in desert areas produces lush thickets of vegetation and concentrates animals. In the immediate vicinity of the CGSA, Little Lake and Haiwee Spring (on the southwestern and northeastern boundaries respectively) are two such habitats. Little Lake is a shallow pond at the south end of Rose Valley. The banks support a growth of cattails (*Typha domingensis*) and bullrush (*Scirpus olneyi*) . Open areas are covered with a low growth of salt grass (*Distichlis spicata*) and yerba mansa (*Anemopsis californica*). Haiwee Spring is a shallow spring-fed stream which runs for about one-quarter mile in a boulder-strewn ravine surrounded by steep rocky hills. Dense willow thickets (*Salix laevigata*) shade much of the water surface. The more open pools and riffles are surrounded by stinging nettle (*Urtica holosericea*) and mats of watercress (*Rorippa-nasturtium aquatica*) and duckweed (*Lemna* sp.).

Both habitats are ideal for amphibians; these require open water for breeding, and they burrow into damp soil, since they rapidly lose moisture through their permeable skins. Red-spotted toads, Pacific treefrogs, western toads (and bullfrogs, which have been introduced by man) all occur at Little Lake. The Great Basin spadefoot toad may well be found here as well. Haiwee Spring supports a relict population of western toads quite isolated by miles of desert from those at Little Lake. Red-spotted toads also occur here.

Desert reptiles are far less dependent upon free water than amphibians. However, many kinds do concentrate near water where cover and food are available, and were observed at both locations; see Table 1. This is especially true of Gilbert's red-tailed skink which seems to require lower temperatures and denser cover than other desert reptiles. They occur in essentially no other habitat in the CGSA. Side-blotched lizards, desert spiny lizards, western fence lizards, Western whiptails, and gopher snakes were relatively common at both locations, as indicated in Table 1; these species seem to be somewhat commoner near water, although they are by no means restricted to this habitat. A few striped whipsnakes and collared lizards were also found at both sites. Although not observed during the study, the Panamint rattlesnake also might be expected at Haiwee Spring or Little Lake, as it shares the apparent preference for moister habitats.

The Panamint alligator lizard (not known in this immediate area) requires special mention. If this rare lizard occurs at all near the CGSA, it would probably be at Haiwee Spring. Dense cover, jumbled rocks to hide among, and nearby surface water all appear to be absolute habitat requirements for this species, Haiwee Spring satisfies all of these.

Table 1. AMPHIBIANS AND REPTILES OF THE CGSA, INYO COUNTY, CALIFORNIA

Community Study Plots
CBS-S (1) - Creosote Bush Scrub Sierra
CBS-RV (2) - Creosote Bush Scrub-Rose Valley
JTW (3) - Joshua Tree Woodland
HS (4) - Haiwee Spring
LL (5) - Little Lake
SS (6) - Shadscale Scrub
CHS (7) - Coso Hot Springs

Abundance
A = abundant
C = common
U = uncommon
O = occasional
R = rare
? = status unknown

Habitat Areas
SP = springs and lakes
BA = alluvial basins
BJ - bajadas and alluvial slopes
WA = washes
RK = rocky areas
CP = cinder and pumice areas
GE = geothermal areas

Common Name	Scientific Name	Abundance in Study Plots (1)	(2)	(3)	(4)	(5)	(6)	(7)	Habitat Areas
AMPHIBIANS									
Great Basin Spadefoot Toad	Scaphiopus intermontanus	- -	- -	- -	- - ? -	- -	- -	- -	BA
*Red-spotted Toad	Bufo punctatus					C-U			SP, WA
*Western Toad	Bufo boreas halophilus				C	C			SP
*Pacific Treefrog	Hyla regilla				C	C-U			SP
*Bullfrog	Rana catesbeiana					C			SP
REPTILES									
Lizards									
*Banded Gecko	Coleonyx variegatus variegatus						C-U	C-U	BA, BJ, WA, RK
*Desert Iguana	Dipsosaurus dorsalis dorsalis						C-O		BA, BJ, WA, CP
*Chuckwalla	Sauromalus obesus obesus							U-O	RK
*Zebra-Tailed Lizard	Callisaurus draconoides		C-U				C		BA, BJ, WA, CP
*Collared Lizard	Crotaphytus insularis bicinctores			U-O	U-O	U-O			WA, RK
*Long-nosed Leopard Lizard	Gambelia wislizenii				U-O		C-U		BA, BJ, WA, CP
*Western Fence Lizard	Sceloporus occidentalis biseriatus	C-U			C-U	C-U			SP, WA, RK
*Desert Spiny Lizard	Sceloporus magister transversus	C-U			C-U	C-U			BJ, WA, RK
*Side-blotched Lizard	Uta stansburiana stejnegeri	A	A	A	A	A	A	C-O	All Habitats
*Desert Horned Lizard	Phrynosoma platyrhinos calidiarum	U-O					U-O	U-O	BA, BJ, WA

Table 1 (continued).

Common Name	Scientific Name	Abundance in Study Plots (1)	(2)	(3)	(4)	(5)	(6)	(7)	Habitat Areas
*Desert Night Lizard	Xantusia vigilis			C-0					BJ, RK
Gilbert's Skink	Eumeces gilberti rubricaudatus				R	R			SP, RK
*Western Whiptail	Cnemidophorus tigris tigris	C			C	C	C	C-0	All Habitats
*Southern Alligator Lizard	Gerrhonotus multicarinatus webbi	R							WA
Panamint Alligator Lizard	Gerrhonotus panamintinus	- - - - - - - - - ?- - - - - - - - - - -							SP
Snakes									
Western Blind Snake	Leptotyphlops humilis	R							BJ, WA, RK
Rosy Boa	Lichanura trivirgata gracia	R							BJ, WA, RK
Spotted Leaf-Nosed Snake	Phyllorhynchus decurtatus perkinsi	- - - - - - - - - ?- - - - - - - - - - -							BA, BJ, WA
*Coachwhip (Red Racer)	Masticophis flagellum piceus	C					C	0	All Habitats
*Striped Whipsnake (Racer)	Masticophis taeniatus taeniatus					U-0	U-0	U-0	SP, BJ, WA, RK
*Western Patch-Nosed Snake	Salvadora hexalepis mojavensis	0					U		BJ, WA, RK
Glossy Snake	Arizona elegans candida								BA, BJ, WA
*Gopher Snake	Pituophis melanoleucus deserticola	C		C	C	C	C	0	All Habitats
Common Kingsnake	Lampropeltis getulus californiae	- - - - - - - - - ? - - - - - - - - - -							BJ, WA, RK
Long-Nosed Snake	Rhinocheilus lecontei lecontei	- - - - - - - - - ? - - - - - - - - - -							BA, BJ, WA
Western Shovel-Nosed Snake	Chionactis occipitalis occipitalis	- - - - - - - - - ? - - - - - - - - - -							BA, BJ, WA, CP
Western Ground Snake	Sonora semiannulata	- - - - - - - - - ? - - - - - - - - - -							BJ, WA
Western Black-headed Snake	Tantilla planiceps utahensis	- - - - - - - - - ? - - - - - - - - - -							BJ, WA, RK
Night Snake	Hypsiglena torquata deserticola	- - - - - - - - - ? - - - - - - - - - -							BJ, RK
Panamint Rattlesnake	Crotalus mitchelli stephensi								WA, RK

Table 1 (continued).

Common Name	Scientific Name	Abundance in Study Plots (1)	(2)	(3)	(4)	(5)	(6)	(7)	Habitat Areas
Northern Pacific Rattlesnake	Crotalus viridis oreganus	- - - - - - - - - - - -0- - - - - - - - - -							WA
Mojave Rattlesnake	Crotalus scutulatus scutulatus	- - - - - - - - - - - -?- - - - - - - - - -							BJ
*Sidewinder	Crotalus cerastes cerastes	C			C-U	C-U	C-U	C-U	BA, BJ, WA, CP
Turtles									
*Desert Tortoise	Gopherus agassizi	- - - - - - - - - - - -0- - - - - - - - - -							BJ, WA

*Asterisk indicates species actually observed during study; other are known in similar habitats within the region. Some species observed in the CGSA did not occur on the 7 study plots.

SHADSCALE SCRUB

This habitat occurs at the lowest and warmest elevations on the CGSA and supports a typically southern Mojave Desert reptile fauna. On the floor of Rose Valley and in other similar areas, shadscale (Atriplex confertifolia) may form almost pure stands (see Flora Technical Report). Also common are cheesebush (Hymenoclea salsola) and goldenhead (Acamptopappus sphaerocephalus). Where the soil is sandy or gravelly, large creosotebushes (Larrea tridentata) encroach into the shadscale along with burroweed (Ambrosia dumosa).

The most abundant lizards in the area were side-blotched lizards, with western whiptail and zebra-tailed lizards also quite common. Desert horned lizards and leopard lizards were seen and are moderately common as are desert iguanas. Banded geckos were observed; these are frequently seen on the paved roads at night.

The most frequently seen snakes in the low basins were coachwhips and gopher snakes. Far less common was the diurnal western patch-nosed snake. On warm nights a number of other species were found to be active, among them sidewinders. Glossy snakes and western shovel-nosed snakes, though not observed during the study, are common in the area, and are also active at night in warm weather. Spotted leaf-nosed snakes and long-nosed snakes, not seen, are also typical of this habitat but are rather uncommon.

The Great Basin spadefoot toad has been found further north in the Owens Valley and may well occur in Rose Valley as well, although its presence there has not yet been confirmed. This interesting amphibian can survive underground for at least two years until heavy rains bring it to the surface to breed. Thus it may go undetected for long periods until cloudbursts and flash floods bring forth raucous choruses of these toads around rain pools. Unlike most other amphibians they can survive well away from permanent water and only require temporary rain pools for breeding.

One desert tortoise was sighted in Rose Valley; this habitat is marginal for the species and it is not certain whether it is a resident of the area (see Protected, Rare, and Endangered Species, below). It may be doubted that breeding populations occur north of the Ridgecrest area (K. Berry, 1979, personal communication).

CREOSOTE BUSH SCRUB

At higher elevations, where substrates become more coarse due to the erosion of gravel and sand from mountains both east and west of Rose Valley, the typical plant community is Creosote Bush Scrub. Creosote bush (Larrea tridentata), burroweed (Ambrosia dumosa) and cheesebush (Hymenoclea salsola) dominate these slopes. These slopes often flatten into small basins or bajadas where shadscale and occasional Joshua trees (Yucca brevifolia) are found.

Except where springs or seeps provide a source of water for red-spotted toad populations, no amphibians occur on the bajadas. Bajadas and alluvial slopes do, however, support a great variety of reptiles including species from both rocky habitats and basins. The most abundant reptiles noted are side-blotched lizards which probably reach their greatest population densities in this habitat. Also very commonly observed were western whiptail lizards, and

and zebra-tailed lizards. Desert iguanas, collared lizards, desert spiny lizards, and desert horned lizards were all present but not common here. Among stands of Joshua trees, desert night lizards may be quite numerous but are seldom seen because of their secretive nocturnal habits. However, several were both observed (in October 1978) and trapped (Spring 1979) in Joshua tree stands. Banded geckos are numerous on bajadas, but are usually only active at night; several were observed.

As in most other habitats in the CGSA, gopher snakes and coachwhips appeared to be the most common snakes. At night, glossy snakes may be expected frequently on the roads, though none were observed during the study. Nearly all of the other species of snakes recorded for the area can be found on bajadas, most of them being nocturnal. Sidewinders are common; not seen but also known to be common in this habitat were western shovel-nosed snakes, spotted leaf-nosed snakes, and night snakes. The diurnal western patch-nosed snake was also found occasionally. Common kingsnakes, rosy boas, and western black-headed snakes are uncommon to rare, and were not seen during this study. The Mojave rattlesnake, a species with extremely toxic venom, occurs in the Indian Wells Valley just to the south, but its presence on the CGSA has not been confirmed. However it could occur on bajadas at lower elevations around Little Lake and Coso Basin. Likewise, the western ground snake has not been taken in this area but it is a possibility, as is the western blind snake. The Little Lake area marks the northwestern range limit for the desert tortoise. Despite the fact that bajadas are the favorite habitat of this species, tortoises are uncommon in this part of the region.

On the warmer rock slopes below 4,500 ft vegetation consists of a low open scrub dominated bycreosotebush with occasional clumps of fairly dense cover. Other important shrubs are burroweed, buckwheat (_Eriogonum inflatum_), cheesebush, with occasional silver cholla (_Opuntia echinocarpa_) and cottontop cactus (_Echinocactus polycephalus_).

Side-blotched lizards were abundant. Also common and conspicuous were western whiptail lizards which forage about between the rocks. Occasional collared lizards and desert spring lizards were seen basking on the larger outcrops and boulders. Chuckwallas are found exclusively among rocks, but since the Coso Range marks the northwestern limit of their range, they are apparently absent from the CGSA, except at the lowest elevations on the lava flows near Little Lake and at the edges of the Coso Basin. Southern alligator lizards are not desert animals _per se_ but individuals were seen on the western edges of the area along washes such as Tunawee and Talus Canyons, which drain the eastern slopes of the Sierra Nevada Range. They have been recorded in the Owens Valley to the north near Olancha and Independence. Desert night lizards (numerous at Site No. 3 in the Joshua tree area) and banded geckos occur in rocky habitat, the latter only occasionally stray from the slopes of the Sierras down canyons such as Tunawee and Talus Canyons to the extreme western edge of the study area.

Washes, which concentrate whatever precipitation falls within their watersheds, usually support denser vegetation than the surrounding terrain. Undercut embankments and a variety of substrates ranging from boulders to sand provide abundant shelter for amphibians and reptiles. In the CGSA washes are usually dominated by conspicuous stands of cheesebush (Hymenoclea) and salt bush (_Atriplex polycarpa_). Washes also cut across other habitats and provide a means of dispersal through them. As a result the numbers and variety of amphibians and reptiles along washes often exceed those in other habitats. The species found in any particular wash depend upon its elevation and adjacent habitats. Therefore almost any species may be found in a wash at some time or other. Certain kinds, though, are typical inhabitants and are listed as such in this report.

At elevations below 4500 feet the most common reptiles occurring in washes were zebra-tailed lizards, western whiptails, side-blotched lizards, and banded geckos. Somewhat less common were desert horned lizards, leopard lizards, and desert iguanas. Though not observed, Gilbert's skinks can occur among rocks and heavy brush, especially near seeps or springs. Gopher snakes and sidewinders were also seen here; and glossy snakes and western shovel-nosed snakes can be expected. Western blind snakes and common king snakes also occur in washes but are quite rare in the CGSA; none were seen.

Generally, above 4500 feet most of the strictly lowland species drop out, although occasional individuals may be seen at elevations over 5000 feet along sandy washes. This is especially true of sidewinders and desert horned lizards, both of which were observed. At higher elevations in the CGSA, washes mainly cut through rocky habitat, and so most of the animals are typical of these areas as well. Western whiptail lizards and side-blotched lizards were still common at higher elevations, but zebra-tailed lizards were rare or absent. Collared lizards, desert spring lizards, and western fence lizards may also be expected in higher washes, especially if boulders are present; gopher snakes, striped whipsnakes and Panamint rattlesnakes also occur. Any surface water in washes usually suggests the presence of red-spotted toads in the higher washes as well as those at lower elevations, though none were seen at the higher elevations.

MIXED DESERT SCRUB

Mixed desert scrub may be found at higher elevations in the CGSA and comprises the predominant plant community above 4500 feet. Vegetation varies considerably with elevation, degree of slope, slope direction, and to a lesser extent with rock type. The physical characteristics of this habitat include ledgy cliffs, boulder-studded slopes, steep canyons, lava flows, and rocky washes.

At these elevations in the CGSA, especially on the cool north-facing slopes, creosotebush and burroweed are entirely absent. Instead a number of cold-tolerant shrubs replace them. These include thornbushes (_Lycium cooperi_ and _Lycium andersonii_), Fremont dalea (_Dalea fremontii_), spiny hop-sage (_Grayia spinosa_), winter fat (_Eurotia lanata_), and cheesebush (_Hymenoclea salsola_).

Side-blotched lizards are observed here but are not nearly as common as at lower elevations. Instead the western fence lizard is much in evidence. Western whiptail lizards, collared lizards, and desert spiny lizards are uncommon here and restricted to warmer south-facing slopes where some individuals were noted. Desert night lizards occur wherever Joshua trees leave fallen limbs on the ground, and some were observed at these elevations (near Site 3).

Gopher snakes and striped racers are the most common snakes on the higher slopes. An occasional Panamint rattlesnake may be found here, though none were noted during the study. The small secretive night snake also occurs on the higher slopes, especially under the debris beneath Joshua trees, but it is uncommon and was not observed.

At some locations within the CGSA, fine cinder and pumice-covered terrain occur. This substrate holds little soil moisture and generally supports a rather sparse vegetative cover of four-winged saltbush (*Atriplex canescens*), cheesebush, buckwheat and various grasses. Because of the extremely arid conditions, no amphibians occur here. Reptiles noted consisted mainly of side-blotched lizards, western whiptail lizards, and occasional leopard lizards. Snakes are scarce, the most likely being gopher snakes, coachwhips, and patch-nosed snakes, all of which were observed.

GEOTHERMAL AREAS: COSO HOT SPRINGS

The immediate vicinity of Coso Hot Springs and Devil's Kitchen is relatively barren with a very scanty reptile fauna. The soils have high contents of sulphates, carbonates, and even mercury salts which make them toxic to all but a few of the hardiest plants. Thus most of the ground is entirely bare or supports only a sparse open growth of buckwheats (*Eriogonum wrightii*, *E. nudum*, and *E. inflatum*). The slopes farther away from these highly mineralic soils have open stands of cheesebush and saltbush.

Despite the presence of some surface water, the high temperatures and mineral content make these areas totally unsuitable for amphibians, and none are found here. Reptiles consisted of a few side-blotched lizards, western whiptail lizards, and an occasional gopher snake or coachwhip, but little else.

SENSITIVE HABITATS

Two important amphibian and reptile habitats seem especially sensitive to disturbance and as such merit special protection. Foremost of these is Haiwee Spring, which lies just outside the CGSA. While this site is protected from general public access by being on the Naval Weapons Center (NWC) withdrawal, it remains as the only significant aquatic habitat for many miles.

Another consideration in the management of this desert spring habitat is the necessity to exclude the bullfrog (*Rana catesbeiana*) which occurs at Little Lake. Bullfrogs are voracious predators on any small animal they can seize and swallow. They have had a detrimental effect on the native fauna wherever they have been introduced and definitely should not be released into sensitive habitats such as Haiwee Spring.

Washes comprise a second sensitive habitat type. The periodic abundance of water flowing through these has produced rich communities of plants and animals especially adapted to withstand the occasional violent flash floods. Wherever possible, any roads should be constructed away from washes.

PROTECTED, RARE, AND ENDANGERED SPECIES

The desert tortoise (Gopherus agassizi) is the State Reptile and is a species fully protected by the State of California, though not included in state or federal listings of rare, threatened or endangered species. It occurs in the Mojave Desert (and also the deserts of Utah, Nevada, Arizona, and Sonora); the CGSA is presumed to be near the northern limit of its area (Pickwell, 1972:62). Although some reports have been made of its presence in the Bishop area (Auffenberg and Franz, 1978), these may have been released pets. Vagrants appear to wander 10 km or more north of denning sites, and the one individual sighted near Coso Junction may have been such a vagrant or a released pet. It is doubtful that any breeding populations occur north of the Ridgecrest area where some likely denning sites might be expected (K. Berry, personal communication). Care should be taken, however, to report any additional sightings and to avoid damage to any specimens encountered.

No rare, endangered or threatened species were observed. However, see comments on the Panamint alligator lizard (under Springs and Lakes, above, and in Summary).

SUMMARY

The CGSA supports a rich and varied herpetofauna consisting of 4 species of amphibians and 31 of reptiles (4 frogs and toads, 14 lizards, 16 snakes and 1 turtle). Two additional snakes, one lizard, and one toad may also occur here, but their status is uncertain at present (see Table 1).

The majority of species are typical of most of the Mojave Desert to the south and east. A few, such as the western toad, Pacific treefrog, southern alligator lizard, and northern Pacific rattlesnake are coastal or Sierran in origin. The remainder are derived from the Great Basin Desert to the north. These include the Great Basin spadefoot toad and striped whipsnake. The bullfrog is native to the eastern United States but has been widely introduced in the west and occurs in Little Lake.

The Panamint alligator lizard has not yet been found on the Coso Geothermal Area but could conceivably occur at Haiwee Spring. This species is only known from small isolated populations in a few steep, rocky live-stream canyons in the Panamint and Inyo Mountains. Its closest relative occurs in southeastern Arizona and northern Mexico. Thus it is a true relict species -- one which had a wider range in the past but has since become isolated by unfavorable environments. It is fully protected as an endangered species by both California and Federal Law. Discovery of additional populations would be of major biological importance.

REFERENCES

Auffenberg, W. and Franz, R., 1978, *Gopherus agassizi* (Cooper) Desert tortoise. *Cat. Amer. Amphib. Rept. Soc. Stud. Amphib. Rept.*, 212.1-.2.

Dixon, James R., 1970, *Coleonyx variegatus* (Baird) Banded Gecko. *Ibid.*, 96.i-.4.

__________ and Fleet, R.R., 1976, Arizona Kennicott, and *Arizona elegans*, Kennecott Glossy Snake. *Ibid.*, 1970.1-.4.

Gorman, G.C., 1965, Distribution of *Lichanura trivirgata* and the status of the species. *Herpetologica* 21, 283-7.

Lais, P. Mike, 1976, *Gerrhonotus multicarinatus* (Blainville) Southern Alligator Lizard. *Cat. Amer. Amphib. Rept.*, *Soc. Stud. Amphib. Rept.*, 187.1-.4.

Miller, A.H. and Stebbins, R.C., 1964, The Lives of Desert Animals in Joshua Tree National Monument. Univ. Calif. Press.

Pough, F. Harvey, 1974, *Uma scoparia*, Cope Mojave Fringed Foot Lizard. *Cat. Amer. Amphib. Rept.*, *Soc. Stud. Amphib. Rept.*, 155.1-.2.

Reynolds, F.B., 1943, Notes on the western glossy snake in captivity. *Copeia* 1943(1), 196-8.

Pickwell, Gayle, 1972, Amphibians and Reptiles of the Pacific States. Stanford Univ. Press, Stanford.

Shaw, C.E., and Campbell, S., 1974, Snakes of the American West. Knopf, New York.

Stebbins, R.C., 1951, Amphibians of Western North America. McGraw-Hill.

__________, 1954, Amphibians and Reptiles of Western North America. McGraw-Hill

__________, 1966, A Field Guide to Western Amphibians and Reptiles. Houghton Mifflin, Boston.

Wilson, Larry D., 1973, *Masticophis* (Baird and Girard) Whipsnakes. *Cat. Amer. Amphib. Rept.*, *Soc. Stud. Amphib. Rept.*, 144.1-.2.

__________, 1973, *Masticophis flagellum* (Shaw) Coachwhip Snake. *Ibid.*, 1945.1.4

Wright, A.H. and A.A., 1951, Handbook of Snakes of the United States and Canada, 2 vols., Cornell Univ. Press, Ithaca.

Zembal, R.L., Massey B.W., and LaRocque, T.E., 1978, Winter season bird population studies in the Coso geothermal area of Inyo County, California. USDI, BLM, Bakersfield contract CA-010-RFP-8-1.

REFERENCES

Auffenberg, W. and Franz, R., 1978, [illegible]. Cat. Amer. Amphib. Rept. [illegible]

Dixon, Janet [illegible], 1970, [illegible]

______ and [illegible], 197[illegible], [illegible]

Gorman, G.C., 1965, [illegible] Copeia [illegible]

Loris, R. [illegible], 1974, [illegible]

Miller, A.H. and Stebbins, R.C., 1964, The Lives of Desert Animals in Joshua Tree National Monument. Univ. Calif. Press.

Pough, F. Harvey, 1970, [illegible]

Reynolds, T.D., 1979, [illegible] Copeia 1979(4), 756-8.

Pickwell, Gayle, 1972, Amphibians and Reptiles of the Pacific States. [illegible]

Shaw, C.E. and Campbell, S., 1974, Snakes of the American West. [illegible]

Stebbins, R.C., 1951, Amphibians of Western North America. [illegible]

______, 1954, Amphibians and Reptiles of Western North America. [illegible]

______, 1966, A Field Guide to Western Reptiles and Amphibians. Houghton Mifflin, Boston.

Wilson, Larry D., 1970, [illegible]

______, 1973, Masticophis flagellum. Cat. Amer. Amphib. Rept. 145.1-4.

Wright, A.H. and A.A., 1957, Handbook of Snakes of the United States and Canada, 2 vols., Comstock Publ. Assoc., Ithaca.

[illegible], R.L., [illegible] and [illegible], 1977, [illegible] population studies in the [illegible] California, 1977. BLM, Bakersfield [illegible]

REPORT III

SURVEY OF AVIFAUNA
IN THE
COSO GEOTHERMAL STUDY AREA

Prepared by

Daniel A. Guthrie

July 1979

TABLE OF CONTENTS

Page

Introduction III-1

Methods III-2

Results and Discussion III-6

Species Sighted III-6

Breeding Bird Surveys III-14

Additional Comments on Resident and Other Breeding Species III-22

Migratory Avifauna III-26

Water Birds III-30

Land Birds III-31

Wintering Avifauna III-32

Water Birds III-32

Land Birds III-35

Raptor Use of CGSA and Vicinity III-35

Major Areas of Raptor Use III-37

Analysis by Species III-37

Endangered, Threatened or Rare Species III-39

Conclusions and Summary III-40

Bibliography III-42

APPENDICES
(Available in Bakersfield District Office of the Bureau of Land Management)

1 Vertebrate Distribution Forms

2 Spot Maps

3 Field Notes

TABLES

		Page No.
1	Dates of CGSA Avifaunal Surveys	III-4
2	Birds Sighted in the CGSA and Immediate Vicinity	III-7
3	Migratory Avifauna in the Study Area	III-27
4	Wintering Avifauna in the Study Area	III-33
5	Raptor Sightings	III-36

FIGURES

1	Avifauna Study Plots in CGSA and Vicinity	III-3

INTRODUCTION

The purpose of this study was to delineate avifaunal utilization patterns within and surrounding the Coso Geothermal Study Area (CGSA), a 113.5 square mile parcel of land located in the northwestern Mojave Desert in southwestern Inyo County, California. The avifaunal study was divided into three parts: a breeding bird study, a winter bird study, and a study of migratory avian populations. Special attention was paid to raptor utilization of the area and to the presence of any endangered, threatened, or rare species. Each study was conducted in such a way as to sample populations in each major vegetational zone within the CGSA and to provide species lists and estimates of population densities.

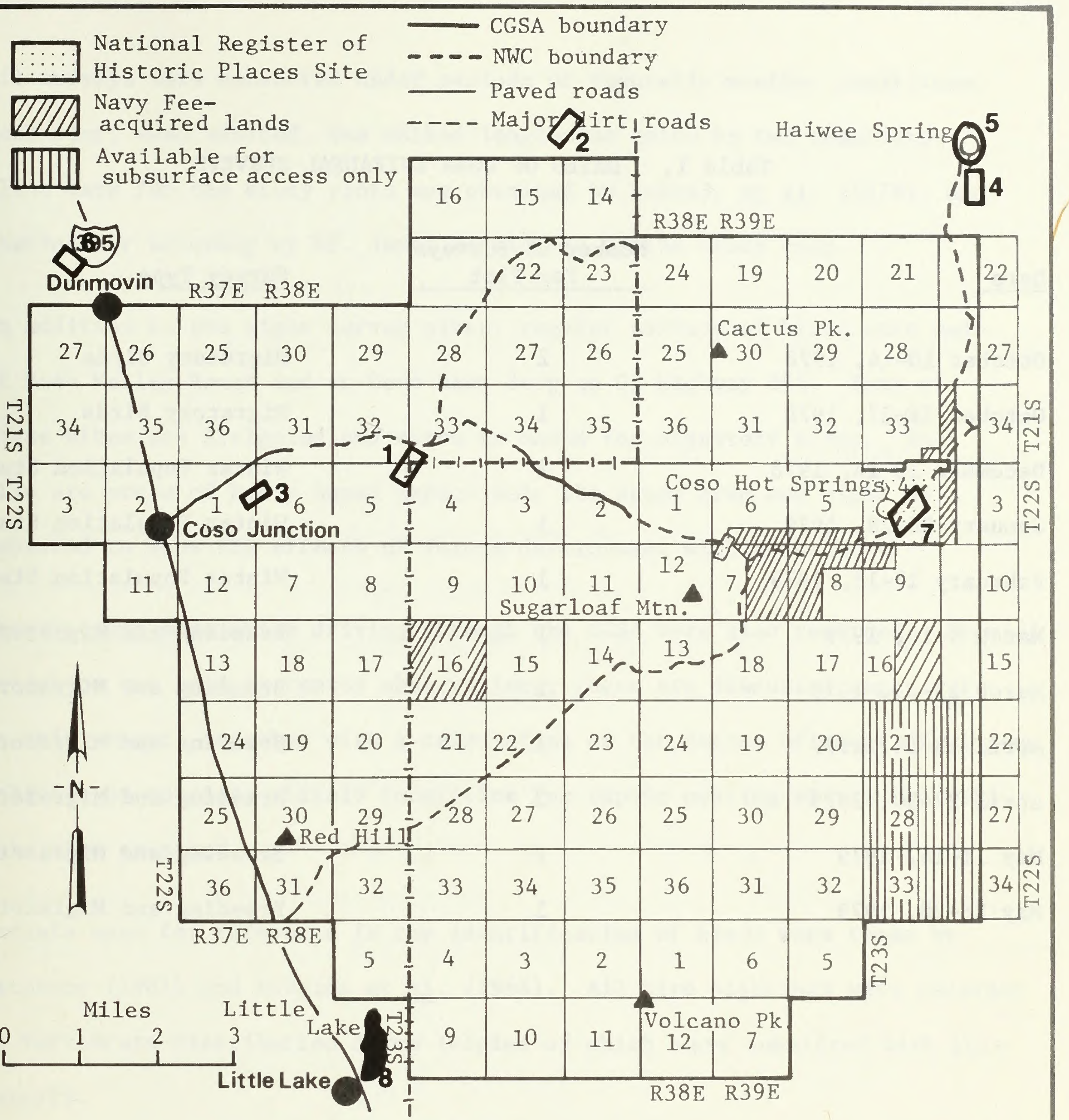
The avifauna of an area can be affected by human activities in many ways. Human presence in an area can disturb nesting of some species. Other species are especially prone to mortality from collision with structures and power lines (see Avery _et al._, 1978), or with vehicular traffic. Finally, habitat destruction, including effects on vegetation and the water table and the introduction of pest species, can affect the bird life in an area. This study was undertaken with these factors in mind so that an impact analysis could be made of the possible effects of geothermal development on the avifauna within the CGSA.

This study was funded by the BLM, Bakersfield District, and accomplished with the cooperation of the Naval Command at the Naval Weapons Center, China Lake, California.

METHODS

The BLM provided eight study plots to be surveyed for migratory and breeding bird populations (see Figure 1). These areas had been selected previously for winter bird studies (Zembal, et al., 1978) and include the major water areas within and immediately proximate to the CGSA: Haiwee Spring, Coso Hot Springs, and Little Lake. They also include four vegetational zones found within CGSA: Joshua Tree Woodland, Creosotebush Scrub (2 surveys), Shadscale Scrub and Desert Scrub. These vegetational zones, defined on the basis of dominant or distinctive species, are found in combination with a variety of other subdominant species, depending upon altitude, soil type, and slope (see Flora Technical Report). However, avifaunal differences between these secondary plant associations are quantitative in nature, being limited to percentage differences for the species that occur, and do not include different avifaunal communities. A study of the eight areas provided gives a fairly accurate indication of the variety in avifaunal diversity to be found within the CGSA. Brief descriptions of the eight areas are included with the discussion of breeding bird surveys below; additional description can be found in American Birds (q.v.).

All eight areas were censused periodically (see Table 1) from October 10, 1978 to June 1, 1979. Surveys followed procedures outlined in Kolb (1965) for winter bird population studies, and in Van Velzen (1972) and Hall (1964) for breeding bird censuses. Spot maps (IBCC, 1970) were used to record all bird sightings (copies of all spot maps were submitted with this report). As winter bird surveys are already available for the eight study areas (Zembal, op.cit.), the study sites were visited only periodically during the months of December, January and February in order to obtain data on population levels to compare with breeding and migratory data obtained in this study and with the previously obtained winter bird data.



1. Creosote Bush Scrub
2. Joshua Tree Woodland
3. Shadscale (Saltbush) Scrub
4. Desert Scrub
5. High Desert Spring (Haiwee)
6. Creosote Bush Scrub on Southern Sierra Alluvium
7. High Desert Hot Springs (Coso)
8. High Desert Reservoir and Shoreline (Little Lake)

Figure 1. AVIFAUNA STUDY PLOTS IN CGSA AND VICINITY

Table 1. DATES OF CGSA AVIFAUNAL SURVEYS

Date	Number of Surveys Per Plot	Survey Type
October 10-14, 1978	2	Migratory Birds
October 26-27, 1978	1	Migratory Birds
December 12-14, 1978	2	Winter Population Study
January 26-28, 1979	1	Winter Population Study
February 17-18, 1979	1	Winter Population Study
March 9-10, 1979	1	Breeding and Migratory Birds
March 23-25, 1979	1	Breeding and Migratory Birds
April 13-14, 1979	1	Breeding and Migratory Birds
April 27-30, 1979	2	Breeding and Migratory Birds
May 11-14, 1979	2	Breeding and Migratory Birds
May 26-28, 1979	1	Breeding and Migratory Birds

All surveys were conducted under periods of favorable weather conditions. Each plot, when visited, was walked lengthwise twice by two observers. Plant data for the study plots was obtained by Zembal, et al. (1978), and checked for accuracy by Dr. James Henrickson of the study team.

In addition to the eight survey plots, regular surveys of birds were made at Rose Valley Ranch and at Coso Rest Stop on US Highway 395. Both of these sites are irrigated and serve as oases for migratory birds. They also are areas of heavy human impact near the study area and might be expected to show the effects of future development within the area.

Observations made while driving through the CGSA were also recorded. Special attention was paid to raptor observations; these are discussed separately in this report, together with a calculation of the degree of usage of various habitats by species. Likely localities for rapotr nesting within the CGSA were also examined.

Manuals used for reference in the identification of birds were those by Peterson (1961) and Robbins et al. (1966). All bird sightings were recorded on Vertebrate Distribution Forms (copies of which were submitted with this report).

All field work was accomplished by Daniel A. Guthrie, Laurie McKean and Kathryn Guthrie. A total of 60 observer days were spent in the field.

RESULTS AND DISCUSSION

Avian observations are presented in several formats: A list of species observed, vertebrate distribution forms, reports on the Breeding Bird surveys, copies of spot maps, and copies of field notes made during this study.

SPECIES SIGHTED

A listing of all species observed within and adjacent to the CGSA during the study period is found in Table 2, together with an indication of the status of each species (whether summering, wintering, or permanent resident species, migrant or eastern vagrant).

The discussion section of this report includes the following: comments on each Breeding Bird Survey; comments on each bird species known to breed within the CGSA and immediate vicinity; a discussion of migratory species' use of the study area; reassessment of wintering bird surveys, based on a review of Zembal (1978) and the additional data accumulated by this study; an analysis of raptor utilization of the CGSA and vicinity based on the above and previous studies; and additional commentary on resident species and other breeding species found within and near the CGSA.

Table 2. BIRDS SIGHTED IN THE CGSA AND IMMEDIATE VICINITY

January 13 - Feburary 20, 1978,[1] October 11, 1978 - May 28, 1979[2]

Species	Scientific Name	Status
Common Loon	Gavia immer	migrant
Western Grebe	Aechmophorus occidentalis	migrant
Eared Grebe	Podiceps nigricollis	migrant
Pied-billed Grebe	Podilymbus podiceps	permanent resident
Double-crested Cormorant	Phalacrocorax auritus	vagrant
Whistling Swan	Olor columbianus	winter
Canada Goose	Branta canadensis	winter
Snow Goose	Chen hyperborea	migrant
Mallard	Anas platyrhynchos	permanent resident and migrant
Gadwall	Anas strepera	permanent resident
Pintail	Anas acuta	winter
Green-winged Teal	Anas crecca	winter
Cinnamon Teal	Anas cyanoptera	permanent resident and migrant
Blue-winged Teal	Anas discors	migrant
American Wigeon	Mareca americana	winter
Northern Shoveler	Spatula clypeata	migrant
Wood Duck	Aix sponsa	migrant
Redhead	Aythya americana	winter
Ring-necked Duck	Aythya collaris	winter
Canvasback	Aythya valisineria	winter
Greater Scaup	Aythya marila	winter
Lesser Scaup	Aythya affinis	winter
Bufflehead	Bucephala albeola	winter

1. Sighted by Zembal, 1978, q.v.
2. Sighted by author.

Table 2. BIRDS SIGHTED IN THE CGSA AND IMMEDIATE VICINITY (cont'd.)

Species	Scientific Name	Status
Ruddy Duck	Oxyura jamaicensis	permanent resident and winter
Common Merganser	Mergus merganser	winter
Sharp-shinned Hawk	Accipiter striatus	winter
Cooper's Hawk	Accipiter cooperii	winter
Red-tailed Hawk	Buteo jamaicensis	permanent resident and winter
Swainson's Hawk	Buteo swainsoni	migrant
Rough-legged Hawk	Buteo lagopus	winter
Ferruginous Hawk	Buteo regalis	winter
Golden Eagle	Aquila chrysaëtos	permanent resident and winter
Marsh Hawk	Circus cyaneus	winter
Osprey	Pandion haliaetus	migrant
Prairie Falcon	Falco mexicanus	permanent resident
American Kestrel	Falco sparverius	permanent resident
California Quail	Lophortyx californicus	permanent resident
Chukar	Alectoris chukar	permanent resident
Great Egret	Casmerodius albus	migrant
Snowy Egret	Leucophoyx thula	migrant
Great Blue Heron	Ardea herodias	permanent resident
Green Heron	Butorides virescens	migrant
Black-crowned Night Heron	Nycticorax nycticorax	migrant
Sora Rail	Porzana carolina	permanent resident
Common Gallinule	Gallinula chloropus	summer resident
American Coot	Fulica americana	winter and permanent resident
Killdeer	Charadrius vociferus	summer resident
Common Snipe	Capella gallinago	migrant

Table 2. BIRDS SIGHTED IN THE CGSA AND IMMEDIATE VICINITY (cont'd.)

Species	Scientific Name	Status
Spotted Sandpiper	Actitis macularia	migrant
Solitary Sandpiper	Tringa solitaria	migrant
Greater Yellowlegs	Totanus melanoleucus	migrant
Least Sandpiper	Erolia minutilla	migrant
Long-billed Dowitcher	Limnodromus scolopaceus	migrant
Western Sandpiper	Ereunetes mauri	migrant
American Avocet	Recurvirostra americana	migrant
Wilson's Phalarope	Steganopus tricolor	migrant
California Gull	Larus californicus	migrant
Bonaparte's Gull	Larus philadelphia	migrant
Mourning Dove	Zenaida macroura	summer resident
Roadrunner	Geococcyx californianus	permanent resident
Barn Owl	Tyto alba	permanent resident
Screech Owl	Otus asio	winter
Great Horned Owl	Bubo virginianus	permanent resident
Burrowing Owl	Speotyto cunicularia	permanent resident
Short-eared Owl	Asio flammeus	migrant
Long-eared Owl	Asio otus	winter
Lesser Nighthawk	Chordeiles acutipennis	summer resident
White-throated Swift	Aeronautes saxatalis	permanent resident
Costa's Hummingbird	Calypte costae	summer resident
Belted Kingfisher	Megaceryle alcyon	migrant
Northern Flicker	Colaptes auratus	winter
Ladder-backed Woodpecker	Dendrocopos scalaris	permanent resident
Western Kingbird	Tyrannus verticalis	summer resident
Cassin's Kingbird	Tyrannus vociferans	migrant

Table 2. BIRDS SIGHTED IN THE CGSA AND IMMEDIATE VICINITY (cont'd.)

Species	Scientific Name	Status
Eastern Kingbird	Tyrannus tyrannus	vagrant
Ash-throated Flycatcher	Myiarchus cinerascens	summer resident
Black Phoebe	Sayornis nigricans	permanent resident
Say's Phoebe	Sayornis saya	permanent resident
Willow Flycatcher	Empidonax brewsteri	migrant
Hammond's Flycatcher	Empidonax hammondii	migrant
Gray Flycatcher	Empidonax wrightii	migrant
Western Wood Peewee	Contopus sordidulus	migrant
Olive-sided Flycatcher	Nuttallornis borealis	migrant
Horned Lark	Eremophila alpestris	permanent resident
Violet-green Swallow	Tachycineta thalassina	summer resident
Tree Swallow	Iridoprocne bicolor	migrant
Rough-winged Swallow	Stelgidopteryx ruficollis	migrant
Barn Swallow	Hirundo rustica	migrant
Steller's Jay	Cyanocitta stelleri	winter
Scrub Jay	Aphelocoma ultramarina	migrant
Black-billed Magpie	Pica pica	local migrant
Common Raven	Corvus corax	permanent resident
Pinyon Jay	Gymnorhinus cyanocephalus	migrant
Mountain Chickadee	Parus gambeli	local migrant
Bewick's Wren	Thryomanes bewickii	permanent resident
Cactus Wren	Campylorhynchus brunneicapillus	permanent resident
Long-billed Marsh Wren	Telmatodytes palustris	winter
Canyon Wren	Catherpes mexicanus	winter
Rock Wren	Salpinctes obsoletus	permanent resident
Mockingbird	Mimus polyglottos	migrant
Le Conte's Thrasher	Toxostoma lecontei	permanent resident

Table 2. BIRDS SIGHTED IN THE CGSA AND IMMEDIATE VICINITY (cont'd.)

Species	Scientific Name	Status
Sage Thrasher	Oreoscoptes montanus	migrant
American Robin	Turdus migratorius	winter
Varied Thrush	Ixoreus naevius	winter
Hermit Thrush	Catharus guttata	winter & migrant
Swainson's Thrush	Hylocichla usturata	migrant
Western Bluebird	Sialia mexicana	winter
Mountain Bluebird	Sialia currucoides	winter
Townsend's Solitaire	Myadestes townsendi	local & migrant
Black-tailed Gnatcatcher	Polioptila melanura	migrant
Blue-grey Gnatcatcher	Polioptila caerulea	summer resident
Ruby-crowned Kinglet	Regulus calendula	winter
Water Pipit	Anthus spinoletta	migrant
Phainopepla	Phainopepla nitens	migrant
Loggerhead Shrike	Lanius ludovicianus	permanent resident
Starling	Sturnus vulgaris	permanent resident
Gray Vireo	Vireo vicinior	migrant
Solitary Vireo	Vireo solitarius	migrant
Warbling Vireo	Vireo gilvus	migrant
Orange-crowned Warbler	Vermivora peregrina	migrant
Nashville Warbler	Vermivora ruficapilla	migrant
Yellow Warbler	Dendroica petechia	migrant
Yellow-rumped Warbler	Dendroica coronata auduboni	winter and migrant
Black-throated Grey Warbler	Dendroica nigrescens	migrant
Townsend's Warbler	Dendroica townsendi	migrant
Palm Warbler	Dendroica palmarum	migrant

Table 2. BIRDS SIGHTED IN THE CGSA AND IMMEDIATE VICINITY (cont'd.)

Species	Scientific Name	Status
Northern Waterthrush	Seiurus noveboracensis	vagrant
Kentucky Warbler	Oporornis formosus	vagrant
MacGillivray's Warbler	Oporornis tolmiei	migrant
Northern Yellowthroat	Geothlypis trichas	permanent resident
Wilson's Warbler	Wilsonia pusilla	migrant
House Sparrow	Passer domesticus	permanent resident
Western Meadowlark	Sturnella neglecta	summer resident, migrant
Yellow-headed Blackbird	Xanthocephalus xanthocephalus	summer resident
Red-winged Blackbird	Agelaius phoeniceus	permanent resident
Scott's Oriole	Icterus parisorum	summer resident
Northern Oriole	Icterus galbula bullockii	summer resident, migrant
Brewer's Blackbird	Euphagus cyanocephalus	permanent resident
Great-tailed Grackle	Cassidix mexicanus	vagrant
Brown-headed Cowbird	Molothrus ater	summer resident
Western Tanager	Piranga ludoviciana	migrant
Black-headed Grosbeak	Pheucticus melanocephalus	migrant
Lazuli Bunting	Passerina amoena	summer resident
Indigo Bunting	Passerina cyanea	vagrant
House Finch	Carpodacus mexicanus	permanent resident
American Goldfinch	Spinus tristis	migrant
Lesser Goldfinch	Spinus psaltria	permanent resident
Pine Siskin	Spinus pinus	migrant
Green-tailed Towhee	Chlorura chlorura	migrant
Rufous-sided Towhee	Pipilo erythrophthalmus	winter
Savannah Sparrow	Passerculus sandwichensis	winter
Vesper Sparrow	Pooecetes gramineus	migrant
Lark Sparrow	Chondestes grammacus	migrant

Table 2. BIRDS SIGHTED IN THE CGSA AND IMMEDIATE VICINITY (cont'd.)

Species	Scientific Name	Status
Black-throated Sparrow	Amphispiza bilineata	permanent resident
Sage Sparrow	Amphispiza belli	permanent resident
Dark-eyed Junco	Junco hyemalis	winter
Chipping Sparrow	Spizella passerina	migrant
Brewer's Sparrow	Spizella breweri	summer resident and migrant
White-crowned Sparrow	Zonotrichia leucophrys	winter
Fox Sparrow	Passerella iliaca	migrant
Lincoln's Sparrow	Melospiza lincolnii	migrant
Song Sparrow	Melospiza melodia	winter

BREEDING BIRD SURVEYS

Surveys were taken in eight previously selected habitats (see Methods, above) found in and near the Coso Geothermal Study Area, during March, April and May, 1979. Reports of these Breeding Bird surveys, substantially as they will be submitted to American Birds for publication, will be found in the pages following. The actual submission for publication in American Birds is in the exact format prescribed by that publication; the format as presented here has been modified slightly for greater readability.

Vertebrate distribution forms, filled out for each species observed during the study, are found in Appendix 1. Appendix 2 contains copies of all spot maps made during visits to study areas. Field notes made during the period of this study (Appendix 3) are in a separate, bound notebook available in the Bakersfield District Office of the Bureau of Land Management.

Creosote Bush Scrub

Location: California, Inyo County, 50m S of Coso Road, 3.9 mi. E. of junction of Coso Road and US Highway 395. The plot lies mostly in the NW corner of Section 4 and NE corner of Section 5, T22S, R38E, Haiwee Reservoir Quadrangle, USGS.

Continuity: New

Size: 25.5 ha. (63 acres), rectangular, 850m x 300m, paced.

Description of Area: See AB 33:1 (WBPS 52). Topography: Elevation, 3820' at northeast end, sloping gradually to 3700' at southwest end. Edge: Alluvial fan, vegetated with Creosote bush scrub, was continuous on all sides of plot.

Weather: Clear on all trips. Temperatures during the study period ranged from 35° to 95° F. Measurable precipitation fell on three days.

Coverage: March 11, 25; April 14, 29, 30; May 13, 14, 27. Total of eight trips averaging 60 minutes between 0730 and 1300; four trips before 1100.

Count: Black-throated Sparrow, 12[1] (47, 19)[2]; Sage Sparrow, 5 (20, 8), Horned Lark, 3 (12, 5); Brewer's Sparrow, 3 (12, 5).

Total: Four species, 23 territorial males (90/km^2, 36/100 acres).

Visitors: Costa's Hummingbird, Raven, Ash-throated Flycatcher, House Finch.

Remarks: Three Black-throated Sparrow nests were found.

This study was supported by the US Bureau of Land Management, Bakersfield District.

Daniel A. Guthrie, Kathryn Guthrie, Joint Science Department, Claremont Colleges, Claremont, California 91711.[3]

---

[1] Territorial males.

[2] Numbers in parentheses indicate density per square kilometer and per 100 acres respectively.

[3] As prescribed by American Birds format, a similar acknowledgment must accompany the report on each habitat site; these are not repeated here.

Joshua Tree Woodland

Location: California, Inyo County, 3.9 mi. E on Coso Road from US Highway 395, then 4.6 mi. N to end of old mine road; Sections 10 and 11, T21S, R38E, Haiwee Reservoir Quadrangle, USGS.

Continuity: New

Size: 26.25 ha. (64.9 acres), rectangular, 1050m x 250m, paced.

Description of Area: See AB 33:1 (WBPS 52). Topography: Elevation, 5040' to 5200' gently rising to north and east from low point at southeast corner. Edge: Bordered on two long axes by 200-foot rocky ridges; at both ends, Joshua Tree Woodland is continuous.

Weather: Clear on all trips. Temperatures during the study period ranged from 35° to 95°F. Measurable precipitation fell on two days.

Coverage: March 11, 25; April 14, 29, 30; May 13, 14, 27, 1979. Total of eight trips averaging 60 minutes between 0630 and 1300; four trips completed before 1030.

Count: Black-throated Sparrow 16 (61, 25); Brewer's Sparrow, 3 (11, 5); Cactus Wren, 2; House Finch, 2; Ladder-backed Woodpecker, 1; Western Kingbird, 1; Ash-throated Flycatcher, 1; Scott's Oriole, 1

Total: Eight species, 27 territorial males (103/km^2, 42/100 acres).

Visitors: Raven, Say's Phoebe, Bewick's Wren, Loggerhead Shrike.

Remarks: Three nests were found: two Black-throated Sparrow, one Cactus Wren. Many more House Finch and Ravens were nesting in rocky outcrops adjacent to site.

Shadscale (Saltbush) Scrub

Location: California, Inyo County, 1 mi. E of US Highway 395 (Coso Junction), 0.4 mi. S of Coso Road on a dirt road along a powerline and 150m W of powerline road; in Section 6, T22S, R38E; and Section 1, T22S, R37E, Haiwee Reservoir Quadrangle, USGS.

Continuity: New

Size: 25.5 ha. (63 acres), rectangular, 300m x 850m, paced.

Description of Area: See AB 33:1 (WBPS 51). Topography: Elevation, 3380'. Gently rolling terrain. Edge: All four sides bounded by similar habitat.

Weather: Temperatures during the study ranged from 40° to 100°F. Measurable precipitation on two days in March.

Coverage: March 11, 25, April 14, 29, 30, May 13, 14, 27, 1979. Total of eight trips averaging 60 minutes between 0830 and 1300; five completed before 1000.

Count: Horned Lark 14 (55, 22); Sage Sparrow 9 (35, 14); Black-throated Sparrow 3 (12, 5); Brewer's Sparrow 3 (12, 5).

Total: Four species, 29 territorial males.

Visitors: Mourning Dove, Costa's Hummingbird, Raven, Brown-headed Cowbird.

Remarks: Four nests were found: two Sage Sparrow, two Horned Lark.

Desert Scrub:

Location: California, Inyo County, 100m SW of Haiwee Spring, within the boundaries of China Lake Naval Weapons Center in Section 15, T21S, R39E, Haiwee Reservoir Quadrangle, USGS.

Continuity: New

Desert Scrub (cont'd.)

Size: 25.5 ha. (63 acres), rectangular, 850m x 200m, paced.

Description of Area: See AB 33:1 (WBPS 55). Topography: Elevation, 4600' to 4800'. The plot slopes moderately to the east. Edge: Similar habitat borders three sides. Steep hills rise just west of the plot. Water: Nearest water is at Haiwee Spring, 100m northeast.

Weather: Temperatures during the study period ranged from 35° to 90°F. Measurable precipitation fell on three days.

Coverage: March 10, 24; April 14, 28, 29; May 12, 13, 26, 1979. Total of eight trips averaging 70 minutes between 0700 and 1500; four trips completed before 0900.

Count: Black-throated Sparrow 10 (40, 16); Horned Lark, 9 (35, 14); Brewer's Sparrow 3 (12, 5); Costa's Hummingbird, 1; Sage Sparrow, 1.

Total: Five species; 24 territorial males (94/km^2, 38/100 acres).

Visitors: Chukar, Raven, House Finch.

Remarks: Four nests were located: Sage Sparrow, 1; Black-throated Sparrow, 3. The area is heavily overgrazed by burros.

High Desert Spring (Haiwee Spring)

Location: California, Inyo County, 5.5 mi. N of Coso Hot Springs by rough dirt road, within the boundaries of China Lake Naval Weapons Center, in Sections 10 and 15, T21S, R39E, Haiwee Reservoir Quadrangle, USGS.

Continuity: New

Size: 5.5 ha. (13.6 acres), irregular shape, 100m x 550m, paced.

Description of Area: See AB 33:1 (WBPS 54). Topography: Elevation, 4680' to 4800'. Edge: Rocky hills of volcanic origin rise steeply on both sides of the canyon; at north (upper) end, above the willow belt, the canyon contains desert wash vegetation; below the willows the canyon broadens into a wide desert wash. Water: Year-round spring; standing pools in the dry season (summer) and a full, flowing stream in the wet season (winter).

High Desert Spring (Haiwee Spring) (cont'd.)

Weather: Clear on all trips. Temperatures during the study period ranged from 35° to 90°F. Measurable precipitation fell on three days.

Coverage: March 10, 24; April 14, 28, 29; May 12, 13, 26, 1979. Total of eight trips averaging 70 minutes between 0700 and 1500; four trips completed before 1000.

Count: Lesser Goldfinch, 8 (145, 59); Costa's Hummingbird, 4 (72, 29); Mourning Dove, 2; Lazuli Bunting, 2; Blue-gray Gnatcatcher, 1; Ash-throated Flycatcher, 1.

Total: Six species, 18 territorial males (327/km^2, 132/100 acres).

Visitors: Chukar, Long-eared Owl, Raven, Rock Wren, House Finch, Black-throated Sparrow.

Remarks: Two Lesser Goldfinch nests were found. Long-eared Owls roosted at the spring for the duration of this study. Chukar, Rock Wren and House Finch nested in nearby rocks and were daily visitors. Up to 40 burro water daily at the spring.

Creosotebush Scrub on Southern Sierra Alluvium

Location: California, Inyo County, 12 mi. N of Little Lake, 1/4 mi. W of US Highway 395, just N of Johnson Canyon, Section 15, T21S, R37E, Haiwee Reservoir Quadrangle, USGS.

Continuity: New

Size: 25.5 ha. (63 acres), rectangular, 850m x 300m, paced.

Description of Area: See AB 33:1 (WBPS 50). Topography: Elevation, 3800' to 4200'. Plot slopes moderately to the east. Edge: The south side is adjacent to Johnson Canyon Wash, the other three sides have habitat continuous with that of the plot. The Sierras rise steeply to the west above the alluvium, and Rose Valley stretches eastward.

Weather: Temperatures ranged from 40° to 100°F. Slight precipitation early in the study period.

Coverage: March 11, 25; April 14, 29, 30; May 13, 14, 27, 1979. Total of eight trips, averaging 60 minutes between 0645 and 1230; six trips completed before 1030.

Creosote Bush Scrub on Southern Sierra Alluvium (cont'd.)

Count: Sage Sparrow, 24 (94, 38); Black-throated Sparrow, 12 (47, 19); Brewer's Sparrow, 2; Mourning Dove, 1; Blue-gray Gnatcatcher, 1.

Total: Five species; 40 territorial males (156/km^2, 63/100 acres).

Visitors: Kestrel, Raven, Costa's Hummingbird, Scott's Oriole, Brown-headed Cowbird.

Remarks: Five nests were found: three Sage Sparrow, two Black-throated Sparrow. All three species of sparrow were initially found in large numbers; numbers decreased as territories were formed, and territorial singing stopped while eggs and young were in the nest, recommencing after fledging.

High Desert Hot Springs (Coso Hot Springs)

Location: California, Inyo County, 11.5 mi. E of US Highway 395 on Coso Road, in the China Lake Naval Weapons Center. In Section 4, T22S, R39E, Haiwee Reservoir Quadrangle, USGS.

Continuity: New

Size: 33.2 ha. (82.1 acres), diamond shaped, with sides 800m, 725m, 540m and 870m, paced.

Description of Area: See AB 33:1 (WBPS 56). Topography: Elevation 3600' to 3640', mostly flat with a gentle downward slope to the north. Edge: Bounded on all of the east and north by Atriplex-Hymenoclea association with the inclusion of Creosote Bush on southwest and southeast. Rocky hills rise to west and south about 500m from plot boundaries; on the north and east sides stretches a broad, flat, Saltbush Scrub-covered valley floor. Water: Runoff from underground hot springs forms a short stream and a cattle trough is also filled during the winter months.

Weather: Clear on all trips. Temperatures during the study period ranged from 40° to 100°F. Slight precipitation early in March.

Coverage: March 10, 24; April 14, 28, 29; May 12, 13, 26, 1979. Total of eight trips, averaging 75 minutes each, between 0700 and 1700; seven trips completed before 1100.

High Desert Hot Springs (Coso Hot Springs) (cont'd)

Count: Say's Phoebe, 3 (9, 4); Costa's Hummingbird, 1; Black-throated Sparrow, 1; Sage Sparrow, 1; Brewer's Sparrow, 1.

Total: Five species; seven territorial males ($21/\text{km}^2$, 8/100 acres).

Visitors: Mourning Dove, Raven, Loggerhead Shrike.

Remarks: Sparrows were found in *Atriplex-Hymenoclea* association. Phoebes nested in buildings (ruins of a resort) and Ravens nested in similar buildings just off plot. Mourning Doves and House Finch were daily visitors to water on the plot, as were up to 50 burros.

High Desert Reservoir and Shoreline (Little Lake)

Location: California, Inyo County, 8 mi. S of Coso Junction on E side of US Highway 395, across from Little Lake Hotel; also small ponds W of US Highway 395, in Sections 8 and 17, T23S, R38E, Little Lake Quadrangle, USGS.

Continuity: New

Size: 31.9 ha. (78.8 acres) of open water, 25 ha. (61.7 acres) of grassy meadow (irregular shape, measured from a topography map with a polar planimeter).

Description of Area: See AB 33:1 (WBPS 57). Topography: Elevation, 3120' to 3200' sloping very gradually to the south.

Weather: Temperatures during the study period ranged from 35° to 95°F. Measurable precipitation fell on three days in March.

Coverage: March 10, 24; April 14, 28; May 12, 13, 26, 1979. Total of seven trips averaging 125 minutes between 0700 and 1800. Two were split trips, with the open water count one day and the shoreline (meadows) another.

Count: Ruddy Duck, 17 (68, 28); Brewer's Blackbird 15 (60, 24); Redwinged Blackbird 15 (60, 24); Mallard, 6 (24, 10); Killdeer, 6 (24, 10); Starling, 5,(20,8); House Sparrow 5 (20, 8); Cinnamon Teal, 4 (16, 6); Coot, 4 (16, 6); Pied-billed Grebe, 2; Gadwall, 2; Violet-green Swallow, 2; Common Gallinule, 1; Sora, 1; Western Kingbird, 1; Black Phoebe, 1; Say's Phoebe, 1; N. Yellowthroat, 1.

High Desert Reservoir and Shoreline (Little Lake) (cont'd.)

Total: 18 species, 80 territorial males ($356/\text{km}^2$, 144/100 acres).

Visitors: Prairie Falcon, Raven, Rock Wren.

Remarks: Four nests were found: two Mallard, two Ruddy Duck; four broods of Coot seen, one Mallard brood. The three visitor species nest on cliffs above lake. Although 200 Coot and 50 Ruddy Duck were on the lake throughout the study period, few were nesting. Starling, House Sparrow, and Say's Phoebe nested in a stable near the lake.

ADDITIONAL COMMENTS ON RESIDENT AND OTHER BREEDING SPECIES

A number of species breed in the area during migratory periods but are not year-round residents; others are summering or wintering species only. The following are additional comments on all species found breeding within the study area, with identification of status and information on locations.

Pied-billed Grebe - A permanent resident on Little Lake, where two or three pairs breed.

Mallard - A permanent resident on Little Lake, where several pairs breed. This species migrates through the area also. Several individuals among Little Lake residents have color patterns indicating cross breeding with feral species, and the resident flock may be escapes.

Gadwall - Three to six pairs nested in the marshes bordering Little Lake and at least a few of these are permanent residents on the lake.

Cinnamon Teal - This species stops on Little Lake during migration. At least three pairs also nest in the ponds on the west side of US Highway 395.

Ruddy Duck - This species winters in large numbers on Little Lake. late spring, the population had dwindled from more than 300 to less than 50 individuals. Several were in breeding plumage and were attempting to nest along the shore of Little Lake.

Raptors - See section on Raptor Use of the CGSA and Vicinity.

California Quail - Although not found in breeding surveys, a few individuals are known to breed on the west side of Rose Valley.

Chukar - This species is commonly found near Haiwee Springs and Coso Hot Springs and more sparingly toward the western portion of the CGSA. Gathering in flocks during fall and winter, the species breaks into pairs in spring and nests in rocky hillsides.

Great Blue Heron - A single individual seems a permanent resident at Little Lake and this species may occasionally breed there.

Sora Rail - A permanent resident and probably breeder in the marshes along the west side of US Highway 395 at Little Lake. At least one pair was present during the study period.

Common Gallinule - Two pairs of Gallinule arrived at Little Lake in May and set up territory preparatory to nesting.

American Coot - Three pairs nested in the small marsh west of US Highway 395 near Little Lake, and another individual nested on the posts south of Little Lake. Over 200 Coot remained on Little Lake during the spring, and presumably some of these also bred.

Killdeer - Six pairs of Killdeer nested on gravel areas around Little Lake.

Mourning Dove - Doves arrived in the CGSA in April and thereafter were often flushed from the ground in pairs. Though no nests were found, this species is presumed to nest widely but sparsely over the CGSA.

Roadrunner - A permanent resident in the CGSA. Courtship calling was head in the rocks adjacent to the Joshua Tree Woodland site in April. They presumably nest in small numbers within the CGSA.

Lesser Nighthawk - A late migrant, this species presumably nests in small numbers.

White-throated Swift - A few individuals nest in the cliffs overlooking Little Lake.

Costa's Hummingbird - A summer resident found sparingly in all habitats within CGSA. Nesting occurred at Haiwee Spring.

Ladder-backed Woodpecker - A permanent resident and breeder in Joshua Tree Woodland.

Western Kingbird - This species summers in the CGSA and prefers to nest where cottonwoods and moisture are available, as around Little Lake, and at Rose Valley Ranch. Three pairs nested at Coso Rest Stop on US Highway 395.

Ash-throated Flycatcher- A summer resident that nests at Haiwee Spring and sparingly within the Joshua Tree Woodland.

Black Phoebe - A permanent resident. One pair nested on the cliff along the west side of Little Lake.

Say's Phoebe - A permanent resident. Several pairs nested in buildings, notably at Coso Hot Springs and at Little Lake.

Horned Lark - Horned Larks are permanent residents in the CGSA. In winter, large flocks occur at lower elevations in Rose Valley and at Coso Hot Springs. In spring, these flocks break up into pairs which spread over the Saltbush Scrub and Desert Scrub habitats and also sandy areas within the Creosote Bush Scrub. Nesting occurs early, with young out of the nest by late May.

Violet-green Swallow - A summer resident. Two or three pairs nested in the rocks around Little Lake.

Common Raven - A permanent resident. Large flocks were observed in Rose Valley in the winter, feeding on road kills and following the cattle and sheep during calving and lambing. In the spring, these flocks broke up into pairs which nested throughout the CGSA. Nests were found in old buildings at Devil's Kitchen and Coso Hot Springs, on cliffs near Little Lake, and on boulders near the pumice mine and Haiwee Spring. The population on the CGSA numbers about 100 individuals.

Bewick's Wren - A few individuals may nest in the Joshua Tree Woodland.

Cactus Wren - A permanent resident in Joshua Tree Woodland.

Rock Wren - This species is a permanent resident in the CGSA. It was observed regularly during winter months at water sources and feeding in the Joshua Tree Woodland. During the spring, the species all but disappeared, moving to rockier hillsides for nesting.

LeConte's Thrasher - A permanent resident. The species nests in small numbers, mostly within Joshua Tree Woodland areas.

Blue-gray Gnatcatcher -	A summer resident that nests in small numbers in Haiwee Spring and in Joshua Tree Woodland and Creosote Bush habitats.
Loggerhead Shrike -	A permanent resident that nests in small numbers in the area. A pair nested in ruins near Coso Hot Springs.
Starling -	A permanent resident, nesting at Rose Valley Ranch and Little Lake, but found throughout the area in small numbers.
Northern Yellowthroat -	A pair are permanent residents at the pond west of US Highway 395 near Little Lake.
House Sparrow -	Several pairs are permanent residents at Rose Valley Ranch and at Little Lake, and about 70 pairs are resident at the Gill Station/Coso Junction Rest Stop, nesting in the cottonwood trees.
Western Meadowlark -	Several pairs nest at Rose Valley Ranch, and a few individuals winter there also.
Yellow-headed Blackbird -	A flock of about 20 individuals summers at the stables at Rose Valley Ranch, nesting there; other individuals were seen at Little Lake.
Red-winged Blackbird -	A flock of 30 are permanent residents that nest beside the ponds south of Little Lake.
Scott's Oriole -	A summer resident that nests in the Joshua Tree Woodland.
Northern Oriole -	This species is a common migrant through CGSA. Several pairs also nested at Coso Rest Stop in the cottonwood trees.
Brewer's Blackbird -	A flock of about 30 individuals are permanent residents at Little Lake and nest in trees near there.
Brown-headed Cowbird -	This species is found in pasture areas on and near the CGSA and probably parasitizes several species of nesting birds.
Lazuli Bunting -	Two pairs were summer residents at Haiwee Spring.
House Finch -	This species is a common permanent resident of the CGSA. They form flocks during the winter months, commonly visiting water at Haiwee Spring and Coso Hot Springs. House Finches nest at Coso Rest Stop and in rocky areas near watering places, visiting Haiwee Spring and Coso Hot Springs daily during the summer.

Lesser Goldfinch -	A few individuals reside permanently at Haiwee Spring. Numbers increase in the summer, and at least eight pairs nested at Haiwee Spring.
Black-throated Sparrow -	This species nests in all habitats within the CGSA, being more common in Creosote Bush Scrub, Desert Scrub, and Joshua Tree Woodland than in Shadscale (or Saltbush) Scrub of the floor of Rose Valley. In winter this species disappears from all but the lowest vegetational zones, a few being found at Coso Hot Springs. A few return in March, when territorial activity dies down while nesting occurs; fledging occurs by late May.
Sage Sparrow -	This species is a year-round resident of CGSA. In winter, large flocks can be found feeding in the lower valleys in Shadscale Scrub, with a few in Creosote. Territorial activity commences in early March when maximum numbers are found in Creosote and Shadscale Scrub. By early April, nesting has commenced and the sparrows become increasingly hard to find. Young birds are flying by early May and the species becomes more visible again. Creosote scrub on the west side of Rose Valley was favored habitat, with smaller numbers of individuals found on the valley floor in Shadscale Scrub or in Desert Scrub habitats.
Brewer's Sparrow -	This species is extremely rare or absent in winter. In late April individuals are found in all habitats, with largest numbers occurred in Desert Scrub, Creosote, and Shadscale habitats. These birds are territorial in distribution and singing. However, most disappear in early May. This disappearance seems due to a movement to other habitats rather than to the species becoming less active. A few pairs nest in the CGSA, and occur in all major vegetational zones.

MIGRATORY AVIFAUNA

All birds that winter or summer on CGSA are also migrants and may show increased numbers in the area during migration. This section deals with species whose abundance in CGSA is greatest during times of migration. Such species are listed in Table 3.

Studies of migration have necessarily focused on mechanisms rather than on individual patterns of migration due to the difficulty of studying the species. Our

Table 3. MIGRATORY AVIFAUNA IN THE STUDY AREA

(Greatest abundance by day per month)

Species	Oct	Dec	Jan	Feb	Mar	Apr	May
Water Birds							
Common Loon	1						3
Eared Grebe	30		1	2		27	35
Western Grebe						2	
Snow Goose					1		
Mallard	40	9	10	14	14	40	12
Cinnamon Teal	20		3	16	45	79	37
Blue-winged Teal						4	1
Northern Shoveler					2	13	4
Wood Duck	1						
Great Egret	2						
Snowy Egret						1	3
Green Heron	1						1
Black-crowned Night Heron						7	2
Spotted Sandpiper						3	13
Solitary Sandpiper						3	1
Greater Yellowlegs						2	
Least Sandpiper						20	5
Long-billed Dowitcher						1	6
Western Sandpiper						8	2
Wilson's Phalarope						8	11
Avocet							1
California Gull	2				1	2	2
Bonaparte's Gull							1

Table 3. MIGRATORY AVIFAUNA IN THE STUDY AREA (cont'd.)

Species	Oct	Dec	Jan	Feb	Mar	Apr	May
Raptors							
Swainson's Hawk							1
Osprey	1						
Short-eared Owl	1						
Land Birds							
Eastern Kingbird							1
Cassin's Kingbird						4	
Willow Flycatcher							1
Hammond's Flycatcher						12	1
Gray Flycatcher						9	4
Western Wood Peewee						2	
Olive-sided Flycatcher						2	
Tree Swallow					1	30	
Rough-winged Swallow					3	2	
Barn Swallow	2				3	4	3
Scrub Jay	1					4	
Pinyon Jay	35						90
Mockingbird						1	1
Sage Thrasher					20		
Swainson's Thrush						3	1
Black-tailed Gnatcatcher						1	
Phainopepla							1
Gray Vireo							1
Solitary Vireo						2	
Warbling Vireo							1

Table 3. MIGRATORY AVIFAUNA IN THE STUDY AREA (cont'd.)

Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Orange-crowned Warbler	2					1	3	2
Nashville Warbler							1	
Yellow Warbler							2	9
Yellow-rumped Warbler	23		1	1	4	7	84	11
Black-throated Grey Warbler		1					1	
Townsend's Warbler							1	
Palm Warbler							1	
Northern Waterthrush								1
Kentucky Warbler							1	
MacGillivray's Warbler							1	2
Wilson's Warbler	1						26	35
Northern Oriole							7	23
Western Tanager							1	5
Black-headed Grosbeak							1	5
American Goldfinch							1	1
Pine Siskin							4	
Green-tailed Towhee							1	
Vesper Sparrow						1		
Indigo Bunting								1
Chipping Sparrow						1	140	3
Fox Sparrow								2
Lincoln's Sparrow							1	

understanding of the needs of migratory birds is, therefore, tentative. Migratory birds navigate using celestial orientation and following local landforms. Sharp geographic boundaries, such as shorelines, river systems and fronts of mountain ranges can act to concentrate migrants along certain routes. The eastern face of the Sierras seems to act as such a geographic boundary and many species of both water and land birds, on reaching the Sierras from the east, migrate along the valleys to the east of the Sierras rather than attempt to cross them. Thus the CGSA/Rose Valley/Little Lake area is an important region for migrants.

As migration needs of water and land birds differ, these two categories will be discussed separately.

Water Birds

Many water birds migrate along the eastern face of the Sierras, including California Gulls, whose major nesting colony in California is on Mono Lake to the north, and Eared Grebes and Wilson's Phalarope, which also concentrate on Mono Lake during migration. Other water birds, including pelicans, shorebirds and ducks, migrating from the Gulf of California and Salton Sea areas to nesting sites in the northern United States and Canada, also migrate along the front of the Sierras. These birds may settle on any body of water along their migration route, including Little Lake, the only permanent body of water in or immediately near the CGSA, and any desert playas that happen to contain water. Such playas occur on the floor of Rose Valley south of Red Hill. A few shore birds were observed feeding on invertebrates in playas in April, 1978, by the author. The value of the playas to migratory water birds is hard to assess. Certainly, Little Lake supports enough aquatic vegetation and invertebrate life to allow some feeing by migrants. However, the lake is small, and probably of recent origin (see Technical Report on Aquatic Species).

Land Birds

Most land birds migrate at night. When day arrives, they settle wherever they are, feeding and resting during the daytime before resuming their migration. Most migratory birds are insectivorous or frugivorous and tend to seek out trees and water during the day. In the deserts, oases especially tend to concentrate migrants. Such concentrations were observed in the study area. In early morning, migratory birds could be found almost anywhere, but during the day they tended to concentrate in the oases within the area, notably Haiwee Spring, Little Lake, Coso Rest Stop, and Rose Valley Ranch. The importance of an oasis as a concentrator of migrants varies with the size of the oasis and, more importantly, its isolation from other oases and its visibility from the air. Thus, Coso Rest Stop, Little Lake and Rose Valley Ranch are excellent concentrators of migratory birds, while Haiwee Spring, lying in a narrow canyon, is less visible from the air and consequently visited by fewer migrants.

Many species of birds normally shy and retiring in their breeding habitat could be readily observed on the lawns at Coso Rest Stop and Rose Valley Ranch during migration. Human activities seemed less important to them at that time than availability of water and food.

In general, migratory species were observed in the frequencies expected for spring migration in California. Several eastern vagrant species were also observed (Eastern Kingbird, Kentucky Warbler, Northern Waterthrush, Indigo Bunting), as might be expected at desert oases during late May.

Several species such as Chipping Sparrow, Gray Vireo, and Pinyon Jay, which normally breed in higher elevations in the Sierras adjacent to CGSA, seem to spend some time at lower altitudes within the CGSA before moving up to their summer habitat. Presumably their migration is timed by day length, and if on arrival weather is intemperate at higher altitudes, they may spend some time at lower altitudes waiting for conditions in the mountains to improve.

WINTERING AVIFAUNA

The birds that primarily winter on CGSA lands (see Table 4) can be conveniently divided into three groups by food type: the water birds, the raptors and the land birds. Water and land birds will be included here while raptors will be discussed in a later section.

Water Birds

Little Lake is the only body of water in or near the CGSA that supports water birds. Numbers of birds on the lake are affected by the hunting season (mid-October to the end of January), during which time up to 150 ducks per week are shot on the lake (according to records provided by the Little Lake Hunt Club).

Duck numbers reach a maximum on Little Lake in February and March after the close of the hunting season, with a maximum of 800 - 1,000 individuals present in one day. Coot, which are not hunted on the lake, numbered up to 1,500 during the winter of 1978-79. These numbers indicate Little Lake supports a significant number of water fowl and that it is an important winter stop for many water birds.

Table 4. WINTERING AVIFAUNA IN THE STUDY AREA

(Maximum Counts Per Month)

Species	Oct	Dec	Jan	Feb	Mar	Apr	May
Water Birds							
Whistling Swan		48					
Canada Goose			14	11	8		
Pintail	200	14	20	15	11	1	2
Green-winged Teal	40	25	14	26	39	30	2
American Wigeon	60	43	40	12		4	
Redhead	50	1	3	9	9	8	5
Ring-necked Duck			5		10	10	
Canvasback		220	200	500	500	3	4
Greater Scaup			4				
Lesser Scaup		2			3	1	
Bufflehead		3	7	3	8	2	
Ruddy Duck	30	195	300	260	350	77	50
Common Merganser		1	2	16	1	1	1
Coot	1730	1500	700	600	340	460	380
Raptors							
Sharp-shinned Hawk	2	1	1		1	2	1
Cooper's Hawk	2	2		1	2		
Red-tailed Hawk	5	8	5	9	6	2	2
Rough-legged Hawk	4	7	2	2			1
Ferruginous Hawk		2	2		1		
Golden Eagle	4	6	1	1	2	1	1
Marsh Hawk	1		1		1	4	
Long-eared Owl	4			5	6	6	3

Table 4. WINTERING AVIFAUNA IN THE STUDY AREA (cont'd.)

Species	Oct	Dec	Jan	Feb	Mar	Apr	May
Land Birds							
Northern Flicker	3	3		2	1		
Mountain Bluebird	8	32	3	15	12		
Ruby-crowned Kinglet	7	3		1	2	4	
White-crowned Sparrow	140	130	30	81	110	60	2

Land Birds

Few of the land birds that occur in the CGSA are wintering species. The major wintering species is the White Crown Sparrow which prefers weedy areas around developed pastures (Little Lake and Rose Valley Ranch) to the native vegetation in the area. According to Zembal, et al. (1978), a small number of Dark-eyed Junco also are present in the winter months. A few species which spend the summer months at higher elevations are mainly nomadic during the winter months and may visit CGSA lands. Among these are Townsend's Solitaire, Varied Thrush and Canyon Wren.

RAPTOR USE OF CGSA AND VICINITY

Zembal et al. (1978) surveyed raptor utilization of CGSA during winter months, making 150 sightings during his study period in January and February, 1978. The present study recorded 203 sightings of raptors, made during the period October 1978 - May 1979. Sightings are listed in Table 5 according to species and locality. These observations were made during 11 visits to the Coso area, each trip including driving 55 miles within the CGSA, and walking an average of 15 miles. While it would be possible to calculate birds per mile observed within the CGSA, this has not been done. Such a calculation is of little value except in large areas of uniform habitat, such as prairies. Furthermore, sightings within the CGSA are undoubtedly repeated observations of the same individuals: for example, the 30 sightings of Long-eared Owls consist of repeated sightings of 6 individuals. The area was covered thoroughly and a calculation of minimum number of individuals (MNI) for each species is possible. (MNI is the number of simultaneous or near simultaneous sightings for each species in the area, or sightings at great enough distance from one another the same day to give confidence that different individuals were involved.) The minimum number of individuals gives a more accurate indication

Table 5. RAPTOR SIGHTINGS

October 11, 1978 - May 27, 1978

	Sharp-shinned Hawk	Cooper's Hawk	Red-tailed Hawk	Swainson's Hawk	Rough-legged Hawk	Ferruginous Hawk	Golden Eagle	Marsh Hawk	Osprey	Prarie Falcon	American Kestrel	Barn Owl	Great Horned Owl	Burrowing Owl	Short-Eared Owl	Long-Eared Owl	Totals
Power Lines			13				10			3	2	2					30
Rose Valley Ranch			7		18	5	2	6		1	12	2		1			54
Little Lake	1		11		1		1		2	3			3				22
Haiwee Springs	6	4	1				1									30	42
Coso Hot Springs		5	2				2				3						12
Creosote (two habitats)			8				6	1			4			11			30
Shadscale and Desert Scrub	1		1	1	1		2	1						2	1		10
Joshua Tree			1							1	1						3
Total	8	9	44	1	20	5	24	8	2	8	22	4	3	14	1	30	203
Minimum Number of Individuals (MNI)	4	2	8	1	7	2	6	2	1	3	4	3	3	4	1	6	

of the use of the CGSA by raptors. Each major area used by raptors will be discussed below, followed by a discussion of each species.

Major Areas of Raptor Use

Rose Valley Ranch. The alfalfa fields and the gopher population supported by them proved to be a major feeding ground for raptors until poisoning and trapping of the gophers commenced in February. One dead Ferruginous Hawk was found on the fields in February.

Power Poles. Stahlecker (1978) has shown that transmission lines play an important role in concentrating raptor activity. This seems especially true for Golden Eagles and Red-tailed Hawks, both of which species seem to prefer hunting in open areas of Saltbush Scrub on the floor of Rose Valley, which is traversed by power poles.

Haiwee Spring. A flock of Long-eared Owls wintered at the springs, as did a Sharp-shinned Hawk and occasionally a Cooper's Hawk.

Little Lake. The cliffs above Little Lake provided perches for several species of raptors (predominantly Golden Eagle, Prairie Falcon, Red-tailed Hawk) which preyed on the wintering duck population and squirrels in the pastures around Little Lake.

Analysis by Species

Sharp-shinned Hawk -	This species is a rare winter visitor to the area. One individual wintered at Haiwee Spring and others were seen during migration near Coso Rest Stop.
Cooper's Hawk -	Individuals wintered at Haiwee Spring and Coso Hot Springs.
Red-tailed Hawk -	This species winters on the floor of Rose Valley, hunting extensively in the fields at Rose Valley Ranch and over the valley floor. Fewer observations were made in the spring, as this population returned to nesting sites. Nesting occurs in cottonwood trees at the south end of Haiwee Reservoir (to the north) and is also suspected near the south end of Little Lake.

Swainson's Hawk - A single individual was seen over the Coso Rest Stop during migration. By Shumway Suffel, Bird Sighting Editor for Los Angeles Audubon Society and well-known Southern California birder.

Rough-legged Hawk - At least seven individuals spent the early part of the winter at Rose Valley Ranch hunting in the fields.

Ferruginous Hawk - Two individuals wintered at Rose Valley ranch.

Golden Eagle - This species hunts during the winter months in the CGSA, preferring the more open habitat of the valley floors. Most sightings during this period were made on power poles, where several individuals roosted during the night. In the past, eagles have nested one mile south of Coso Hot Springs on lava cliffs. Absence of adult eagles during the late spring indicates no current nesting on CGSA. The nearest known nesting is on the cliffs above Haiwee Reservoir.

Marsh Hawk - Two individuals wintered in Rose Valley, hunting over the alfalfa fields and valley floor.

Osprey - An osprey visited Little Lake during fall migration.

Prairie Falcon - Individual falcons were observed ranging widely over the CGSA during the winter months, with most sightings concentrated in the vicinity of Little Lake. A pair of prairie falcons nested on the cliff to the east of Little Lake during the spring of 1979.

American Kestrel - Kestrels nest one mile south of Coso Hot Springs on lava cliffs and also in the vicinity of Rose Valley Ranch. Winter sightings of these birds were made near Coso Hot Springs and Rose Valley Ranch.

Barn Owl - Barn owls were observed hunting over Rose Valley Ranch during winter months and two owls were found dead along US Highway 395 during the study period. Nesting probably occurs within the study area.

Great Horned Owl - This species nested on the cliffs south of Fossil Falls, (north of Little Lake) and has also been found nesting on cliffs in the deep canyons 1 mile northeast of Coso Hot Springs to the east of the CGSA.

Burrowing Owl - A year-round resident of the CGSA. A pair nested along the side of the road leading to the pumice mine (one mile north of the junction with the Coso access road). Pairs were seen sporadically in the Creosotebush and Shadscale scrub plots. The species is uncommon but regular in sandy soil areas.

Short-eared Owl - A single individual was observed hunting over a playa in Rose Valley during fall migration.

Long-eared Owl - A flock of six individuals wintered at Haiwee Spring. In the spring, most of these disappeared, presumably to nest at higher elevations adjacent to CGSA.

Screech Owl - Zembal (1978) found a single individual in the CGSA. None were observed during this study.

ENDANGERED, THREATENED OR RARE SPECIES ENCOUNTERED

No rare, threatened, or endangered species were sighted within the CGSA or its immediate vicinity. The raptor species observed are relatively scarce; and the larger predators, such as the Golden Eagle and the Prairie Falcon, are birds of considerable interest to many persons. As the above discussion indicates, the CGSA and its vicinity include several areas frequented by these species. They are not, however, contained in any Federal or State listing of endangered, threatened or rare species.

CONCLUSIONS AND SUMMARY

Wintering Avifauna. Species found in CGSA only in winter are mostly water birds using Little Lake, and raptors hunting in the Shadscale Scrub (Atriplex sp.) of Rose Valley. The alfalfa fields of Rose Valley Ranch are especially attractive to these latter species. Only a few land birds winter on the CGSA or vicinity and these are mostly found near water or areas of imported weeds.

Migratory Avifauna. A large number of waterbirds stop at Little Lake and in Rose Valley oases during migration, and land birds migrating along the east face of the Sierra may also land in the CGSA, especially at places with trees or water.

Breeding Species. The largest number of breeding species is found at Little Lake. Joshua Tree Woodland also supports a wide variety of breeding species. The breeding avifauna of the Creosote Scrub, Desert Scrub and Shadscale Scrub consists almost entirely of four species: Horned Lark, Black-throated Sparrow, Sage Sparrow and Brewer's Sparrow. Rocky areas support several species of raptors and also Roadrunners, Chukar and Rock Wren. A Prairie Falcon nested near Little Lake during 1979.

Raptors. Raptor utilization of CGSA is heaviest during winter months. Raptors known to nest in the CGSA are Kestrel, Golden Eagle, Red-tailed Hawk, Barn Owl, Great Horned Owl and Prairie Falcon

Habitats where raptor nesting is known or likely include cliffs above Little Lake, the 200-foot-high rocky ridges bordering the Joshua Tree Woodland habitat (see Breeding Bird Surveys, above), the hills near Haiwee Spring, the trees at the south end of Haiwee Reservoir, lava cliffs one mile south of Coso Hot Springs, and other high points. Man-made structures can also enhance nesting opportunities . Favorite roosting places are power transmission lines.

Summary

One hundred and sixty-three species have been recorded within and near the CGSA. Of these, 55 breed within the area, 33 of these permanently residing in the CGSA and vicinity. An additional 75 species have been recorded as migrants and an additional 33 species winter in the area.

Surveys of the eight habitat types, and of additional oases within the area, together with observations made while driving in the CGSA, yielded data which give a reasonably clear idea of the distribution of species and numbers in the various habitats comprising the study area. While individuals of several species can be expected to occur in all parts of the CGSA, in each of the types of habitat,it is clear that certain areas are of more importance than others to the avifauna of the region. In terms of numbers of species and numbers of individuals, oases (Little Lake, Coso Rest Stop, Rose Valley Ranch, and Haiwee Spring) are significant points of concentration for residents and other species; Little Lake is particularly important for water birds and for both water and land bird migrants. Of the arid areas, Joshua Tree Woodland habitat contained the greatest numbers and greatest variety of species (see Flora Technical Report for delineation of Joshua Tree Woodland areas). While birds were observed at Coso Hot Springs, ground cover there is quite sparse, and the area has been greatly disturbed by human use and the presence of feral burros. Within the CGSA and immediate vicinity, raptor usage is concentrated along power lines; raptor nesting is known or probable at many points of high elevation. No endangered, threatened or rare species of avifauna were observed during the study.

BIBLIOGRAPHY

American Birds. Vol. 33, No. 1. Winter Bird Population Studies: 50-57.

Avery, Michael L., Paul F. Springer and Nancy S. Dailey, 1978. "Avian Mortality at Man-Made Structures, with Annotated Bibliograpy."

Hall, G., 1964. "Breeding Bird Census -- Why and How." Audubon Field Notes 18:413-416.

IBCC (International Bird Census Committee), 1970. "Recommendations for an International Standard for a Mapping Method in Bird Census Work."

Jehl, Joseph R. Jr., Suzanne I. Bond, Phillip Unitt and R. Guy McCaskie, 1977. "Annotated Bibliography on Seasonal Movements of Migratory and Resident Birds in the California Desert." Report to US Department of the Interior, Bureau of Land Management, Riverside District.

Kolb, H., 1965. "The Audubon Winter Bird-Population Study." Audubon Field Notes 18:413-416.

Peterson, R.T., 1961. A Field Guide to Western Birds. The Riverside Press, Cambridge, Mass. 366 pp.

Robbins, C.S., B. Brunn, and H. S. Zim, 1966. Birds of North America. Western Publishing Co., Inc. Racine, Wisconsin, 340 pp.

Stahlecker, Dale W., 1978. "Effect of a New Transmission Line on Wintering Prairie Raptors." Condor, 80:444-446.

Van Velzen, Willet T., 1972. "Breeding-bird Census Instructions." American Birds, 26:927-31.

Zembal, Richard, Barbara W. Massey and Thomas E. LaRocque, 1978. "Winter Season Bird Populations Studies in the Coso Geothermal Area of Inyo County, California." Report to US Department of the Interior, Bureau of Land Management, Bakersfield District. Also in American Birds, 33:1, q.v.

REPORT IV

SURVEY OF SMALL MAMMALS
AND CARNIVORES
IN THE COSO GEOTHERMAL STUDY AREA

Prepared by

Philip Leitner

July 1979

TABLE OF CONTENTS

Page

I. Introductory Note IV-1

II. Bats IV-2

A. Introduction IV-2

B. Methods IV-2

C. Results IV-3

D. Discussion IV-7

E. Summary IV-17

III. Rodents IV-18

A. Introduction IV-18

B. Methods IV-18

C. Results IV-24

D. Discussion IV-37

E. Status of Mohave Ground Squirrel IV-42

F. Summary IV-45

IV. Carnivores IV-47

A. Introduction IV-47

B. Methods IV-47

C. Results IV-50

D. Discussion IV-54

E. Summary IV-60

V. Rare, Threatened and Endangered Species: Summary IV-61

VI. Literature Cited IV-62

TABLES

Table	Approximate Title/Subject	Page
(Bat Report)		
1.	Species captured by mist netting, October 1978	IV-5
2.	Numbers captured by mist netting, October 1978, by location, by date	IV-6
3.	Species captured by mist netting, May-July 1979	IV-8
4.	Numbers captured by mist netting May-July 1979, by location, by date	IV-9
(Rodent Report)		
1.	Live-trap sampling sites and trapping effort, summer 1979	IV-20
2.	Rodent and lagomorph fauna of CGSA	IV-25
3.	Results of live-trapping, nocturnal rodents	IV-26
4.	Total captures, nocturnal rodents	IV-27
5.	Relative abundance of nocturnal species	IV-28
6.	Summary, nocturnal captures, Rose Valley	IV-30
7.	Summary, nocturnal captures, Sugarloaf	IV-31
8.	Summary, nocturnal captures, Sierra Slope	IV-32
9.	Summary, nocturnal captures, Volcano Peak	IV-33
10.	Summary, nocturnal captures, Pumice Mine	IV-34
11.	Summary of results, ground squirrel live-trapping, eight sites	IV-35
12.	Summary of results, ground squirrel live-trapping, five main sites	IV-36
13.	Summary of ground squirrel captures, three supplemental sites	IV-38
14.	Rodent and lagomorph species recorded in southwest Inyo County in three studies	IV-39

TABLES (cont'd)

Page

(Carnivore Report)

1. Species recorded at tracking stations, October 1978 IV-52

2. Species recorded on tracking station transects, October 1978 IV-53

3. Carnivores of the CGSA IV-55

FIGURES

Figure

(Bat Report)

1. Locations of Mist Net Sampling Sites IV- 4

(Rodent Report)

1. Locations of Nocturnal Rodent Trapping Sites IV-21

2. Locations of Ground Squirrel Trapping Sites IV-23

(Carnivore Report)

1. Locations of Carnivore Track Stations: Preliminary Study IV-49

2. Locations of Carnivore Track Stations: Intensive Study IV-51

I. INTRODUCTORY NOTE

The 1978-1979 study of small mammals and carnivores within the Coso Geothermal Study Area and immediate environs is presented here in three discrete reports, each with its own self-contained series of consecutively numbered tables and maps. Thus, Sections II, III and IV discuss, respectively, bats, rodents, and carnivores. A summary section on rare, threatened and endangered species encountered is presented in Section V.

II. BATS

A. INTRODUCTION

This sampling program was designed to inventory the bat fauna in the Coso Geothermal Study Area (CGSA). The occurrence of various species was determined by sampling at night with mist nets over water sources and at other places where bat activity could be concentrated. During the day mine tunnels and old buildings were checked for the presence of bat colonies.

The increased human activity that will accompany geothermal development may result in disturbance of bat populations in buildings and mines. This disturbance can be of critical importance if it occurs during hibernation or when females and young form maternity colonies. In order to protect bat populations and their habitats, it was necessary to collect baseline data on the species present and their distribution within the CGSA.

B. METHODS

Nocturnal bat activity is usually greatest in the vicinity of open water, especially in desert areas where insect prey is most abundant near such places as springs, ponds, and water holes. Bats may fly up to several miles from their daytime roosts to feed and drink at these locations. Many species also use buildings, mines, and natural shelters as night roosting spots. By the use of mist nets, bat populations can be conveniently sampled at water sources, night roosts, and other habitat features where their flight activity is concentrated.

In this study, bats were captured in 1-inch mesh black monofilament nylon mist nets stretched over open water and near night roosts. All nets were 7 feet in height, but different lengths (18, 30, or 60 feet) were used as appropriate in particular sampling situations. From one to three nets were used each night as needed for effective coverage. They were generally set at dusk and tended until midnight, although netting was sometimes stopped earlier due to lack of bat activity. All bats captured were removed from the nets, identified to species and sex, and reproductive condition noted. They were then released unharmed at a short distance from the sampling location.

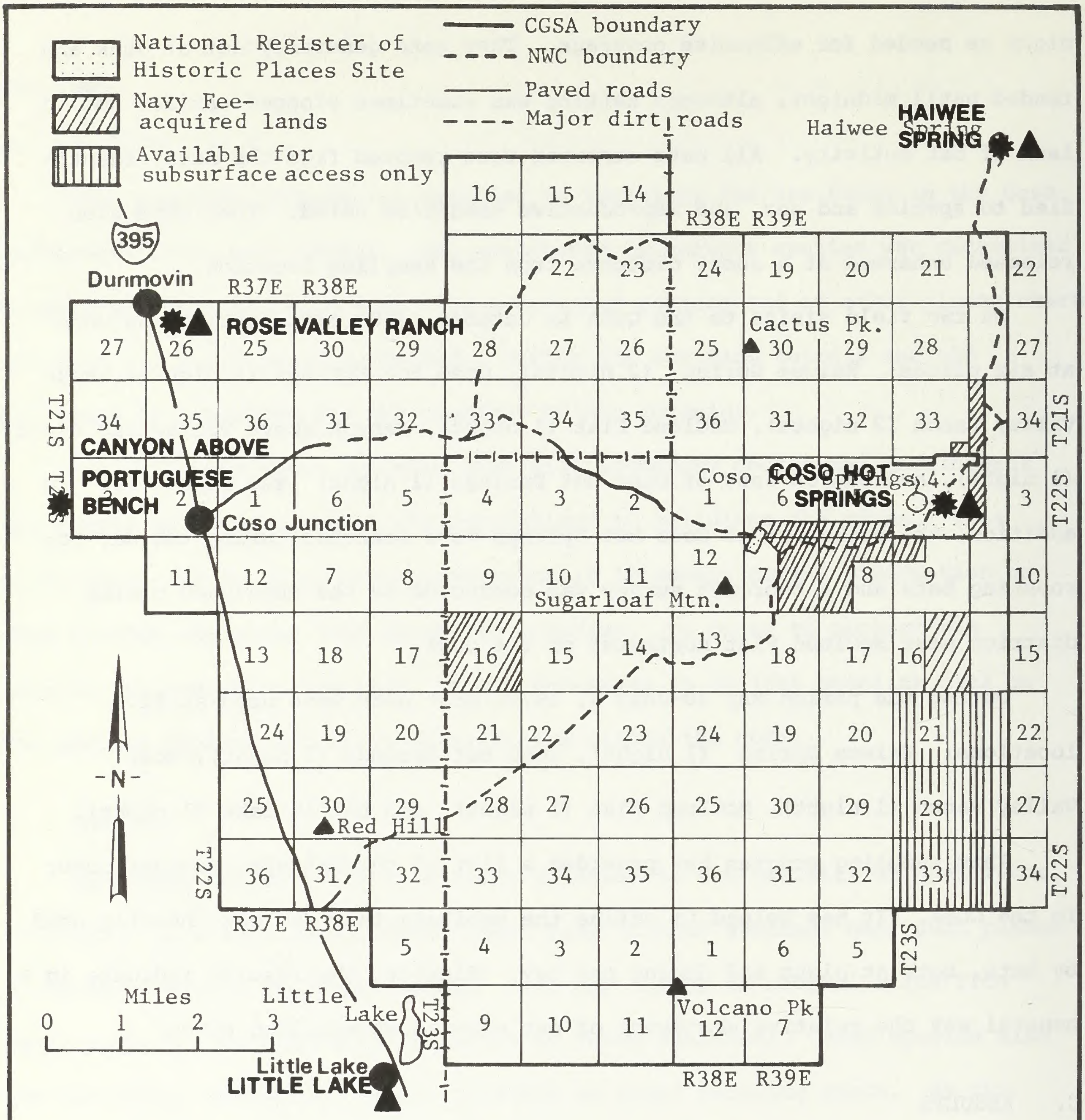
On two field visits to the CGSA in October 1978, mist netting was done at six places: Haiwee Spring (2 nights), Coso Hot Springs (2 nights), Rose Valley Ranch (2 nights), McCloud Flat (1 night), canyon above Portuguese Bench (1 night), and canyon east of Coso Hot Springs (1 night) (see Figure 1). In addition, the buildings at Coso Hot Springs were searched during the day for roosting bats and a thorough survey was conducted in the abandoned mining district near McCloud Flat northwest of the CGSA.

During the period May 30-July 2, 1979, mist nets were used at five locations: Haiwee Spring (1 night), Coso Hot Springs (1 night), Rose Valley Ranch (1 night), McCloud Flat (1 night), and Little Lake (1 night).

This sampling program has provided a list of the bat species that occur in the CGSA. It has helped to define the habitats that are most heavily used by bats, both at night and during the day. Finally, the results indicate in a general way the relative abundance of bat species at sampling sites.

C. RESULTS

A total of 42 bats belonging to seven species was taken in mist nets during October 1978 (Table 1). Capture success varied from 20 bats of five species on the evening of October 5 at Haiwee Spring to no bats taken at Rose Valley Ranch and in the canyon above Portuguese Bench (Table 2). Evidence from mist net sampling indicates that Haiwee Spring is by far the most heavily used location surveyed. Thirty of the 42 bats captured in



Locations of Mist Sampling Sites

✹ October 1978

▲ May-July 1979

Additional sampling sites not shown on map:
McCloud Flat, Section 32, T20S, R38E;
Canyon East of Coso Hot Springs,
Section 2, T22S, R39E.

Figure 1. BAT REPORT

TABLE 1. Summary of bat species captured by mist netting during the October 1978 sampling period. Mist nets were used on a total of 9 nights at 6 different locations.

Bat Species		Number Captured
Long-legged myotis	Myotis volans	5
California myotis	Myotis californicus	6
Small-footed myotis	Myotis leibii	4
Silver-haired bat	Lasionycteris noctivagans	1
Western pipistrelle	Pipistrellus hesperus	17
Townsend's big-eared bat	Plecotus townsendii	5
Pallid bat	Antrozous pallidus	4

TABLE 2. Bats captured by mist netting at various locations in and near the Coso Geothermal Study Area during the October 1978 sampling period.

Date & Location	Bat Species		Number Captured	
			Male	Female
October 5, 1978				
Haiwee Spring	Long-legged myotis	*Myotis volans*	1	2
	California myotis	*Myotis californicus*	3	2
	Small-footed myotis	*Myotis leibii*	1	2
	Western pipistrelle	*Pipistrellus hesperus*	3	5
	Townsend's big-eared bat	*Plecotus townsendii*	1	0
October 6, 1978				
Canyon east of Coso Hot Springs	Western pipistrelle	*Pipistrellus hesperus*	2	1
October 7, 1978				
Coso Hot Springs	Western pipistrelle	*Pipistrellus hesperus*	1	2
	Pallid bat	*Antrozous pallidus*	2	2
October 23, 1978				
Haiwee Spring	Long-legged myotis	*Myotis volans*	1	1
	California myotis	*Myotis californicus*	1	0
	Silver-haired bat	*Lasionycteris noctivagans*	0	1
	Western pipistrelle	*Pipistrellus hesperus*	1	1
	Townsend's big-eared bat	*Plecotus townsendii*	1	1
October 24, 1978				
McCloud Flat	Small-footed myotis	*Myotis leibii*	0	1
	Western pipistrelle	*Pipistrellus hesperus*	1	0
October 25, 1978 Coso Hot Springs October 26, 1978 Cyn. above Portuguese Bench October 27, 1978 Rose Valley Ranch	No bats taken			

October were taken there and six of the seven species recorded for the CGSA were present in that sample. Buildings at Coso Hot Springs were used regularly by pallid bats (Antrozous pallidus) for night roosting in October. No sign of daytime roosting was found at that time. Townsend's big-eared bats (Plecotus townsendii) were captured with hand nets at a mine tunnel near McCloud Flat, north of the CGSA. No other species were taken in the mines and there was no evidence of large bat colonies in this mining district.

During the summer sampling period, a total of 134 bats of five species were collected in mist nets (Table 3). The catch at each sampling site is indicated in Table 4. Haiwee Spring was again the locality where greatest capture success and number of species was noted, with 102 individuals of five species taken. A small pond at McCloud Flat yielded 19 bats of four species during one evening of mist netting. Night-roosting pallid bats and California myotis (Myotis californicus) were captured by mist-netting at the Coso Hot Springs buildings. No bats were taken at Rose Valley Ranch or Little Lake.

D. DISCUSSION

On the basis of present evidence, five species appear to make up the permanent bat fauna of the CGSA: California myotis, small-footed myotis (Myotis leibii), western pipistrelle (Pipistrellus hesperus), Townsend's big-eared bat, and pallid bat. Individuals of these five species were collected in both fall 1978 and summer 1979 sampling periods. Females of all five species were found to be currently or recently lactating when captured in June and July 1979, indicating that resident breeding populations are present. Furthermore, these same species were also taken by mist netting in the summer of 1978 by Zembal, et al. (1978) at four locations in the eastern portion of the CGSA.

TABLE 3. Summary of bat species captured by mist netting during the May 30-July 2, 1979 sampling period. Mist nets were used on a total of 5 nights at 5 different locations.

Bat Species		Number Captured
California myotis	Myotis californicus	23
Small-footed myotis	Myotis leibii	2
Western pipistrelle	Pipistrellus hesperus	94
Townsend's big-eared bat	Plecotus townsendii	1
Pallid bat	Antrozous pallidus	14

TABLE 4. Bats captured by mist netting at various locations in and near the Coso Geothermal Study Area during the May 30-July 2, 1979 sampling period.

Date & Location	Bat Species		Number Captured	
			Male	Female
May 30, 1979				
Rose Valley Ranch	No bats taken			
June 7, 1979				
Coso Hot Springs	California myotis	*Myotis californicus*	4	0
	Pallid bat	*Antrozous pallidus*	0	9
June 30, 1979				
Haiwee Spring	California myotis	*Myotis californicus*	1	2
	Small-footed myotis	*Myotis leibii*	0	1
	Western pipistrelle	*Pipistrellus hesperus*	9	84
	Townsend's big-eared bat	*Plecotus townsendii*	0	1
	Pallid bat	*Antrozous pallidus*	2	2
July 1, 1979				
Little Lake	No bats taken			
July 2, 1979				
McCloud Flat	California myotis	*Myotis californicus*	2	14
	Small-footed myotis	*Myotis leibii*	1	0
	Western pipistrelle	*Pipistrellus hesperus*	1	0
	Pallid bat	*Antrozous pallidus*	1	0

TABLE 3. Summary of bat species captured by mist netting during the May 30-July 2, 1979 sampling period. Mist nets were used on a total of 5 nights at 5 different locations.

Bat Species		Number Captured
California myotis	_Myotis californicus_	23
Small-footed myotis	_Myotis leibii_	2
Western pipistrelle	_Pipistrellus hesperus_	94
Townsend's big-eared bat	_Plecotus townsendii_	1
Pallid bat	_Antrozous pallidus_	14

TABLE 4. Bats captured by mist netting at various locations in and near the Coso Geothermal Study Area during the May 30-July 2, 1979 sampling period.

Date & Location	Bat Species		Number Captured	
			Male	Female
May 30, 1979 Rose Valley Ranch	No bats taken			
June 7, 1979 Coso Hot Springs	California myotis	*Myotis californicus*	4	0
	Pallid bat	*Antrozous pallidus*	0	9
June 30, 1979 Haiwee Spring	California myotis	*Myotis californicus*	1	2
	Small-footed myotis	*Myotis leibii*	0	1
	Western pipistrelle	*Pipistrellus hesperus*	9	84
	Townsend's big-eared bat	*Plecotus townsendii*	0	1
	Pallid bat	*Antrozous pallidus*	2	2
July 1, 1979 Little Lake	No bats taken			
July 2, 1979 McCloud Flat	California myotis	*Myotis californicus*	2	14
	Small-footed myotis	*Myotis leibii*	1	0
	Western pipistrelle	*Pipistrellus hesperus*	1	0
	Pallid bat	*Antrozous pallidus*	1	0

Museum records confirm that all five species have been collected in the past at Inyo County localities immediately adjacent to the CGSA (Patricia Brown, personal communication). Furthermore, numerous specimens from the desert areas of San Bernardino and Kern Counties are found in museum collections. These bats are among the most abundant and widespread species throughout the desert regions of California. They all appear to roost during the day in crevices in rocky outcrops, cliffs, and canyon walls, often flying a mile or more to drink at springs and water holes in the first hours after dark.

The long-legged myotis (Myotis volans) was taken at Haiwee Spring on one occasion during October 1978. It has not been collected in the summer and probably is not a permanent resident of the CGSA. This species is common in forested habitat throughout the western United States, but appears to be absent from the low desert areas of the Southwest (Barbour & Davis, 1969). There are museum specimens collected in spring and summer from the White Mountains and from the Sierra Nevada as far south as Walker Pass (Patricia Brown, personal communication). Several spring and summer records exist for mountain ranges in northeastern San Bernardino County down to elevations as low as 4000 feet. The closest previous record for the long-legged myotis was a specimen taken in October about 35 miles northeast of Haiwee Spring at 6200 feet in the Inyo Mountains. Thus, individuals of this species may regularly move into the Coso and Inyo Ranges in the fall.

The single silver-haired bat (Lasionycteris noctivagans) collected in October 1978 at Haiwee Spring is of particular interest since only two other records exist for the entire Mohave Desert (Patricia Brown, personal communication). These specimens were taken at the Furnace Creek Ranch in Death Valley (October 19, 1933) and at Ballarat in the Panamint Mountains

(September 20, 1975). Silver-haired bats are known to migrate long distances between their summer range in Canada and the northern Rocky Mountains and wintering areas along the Pacific Coast and in the Southwest (Barbour & Davis, 1969). The three Inyo County records almost certainly were of bats on fall migration; silver-haired bats would also be expected to move through the region in May on their way north. The willows and rocky cliffs around Haiwee Spring should provide excellent diurnal roosting places for migrants. The species is probably a much more common spring and fall transient through the Mohave Desert than existing data would indicate.

The western mastiff bat (Eumops perotis) was determined to be present in the vicinity of the CGSA by Zembal, et al. (1978). On several occasions during the summer of 1978 these investigators saw western mastiff bats emerging at dusk from a canyon in the lava flows about two miles east of Coso Hot Springs. We were not able to confirm these observations during the present study, but this is not surprising since colonies are known to shift among alternate diurnal roosts and to undertake seasonal movements of unknown extent as well (Krutzsch, 1955). The western mastiff bat is the largest member of its order in the United States, with a wingspread of almost two feet. These fast, wide-ranging bats hunt for flying insects at altitudes as much as 1000 feet above the ground (Vaughn, 1959). Day roosts are typically in rock crevices in high, vertical cliffs, although colonies do occur in large buildings. Colonies are generally small, nearly always under 100 individuals. The species is found from central California through the southern parts of Arizona, Nevada, and New Mexico to western Texas and northern Mexico (Barbour & Davis, 1969). In California, records are concentrated on the coastal slopes from San Diego to Los Angeles Counties, along the Colorado River, and from the central Coast Range east across the

San Joaquin Valley to the Sierra Nevada foothills (Eger, 1977). There are no museum specimens or other reports for the western mastiff bat in the Mohave Desert. The closest previous record listed by Eger (1977) is about 70 miles southwest of the CGSA in Kern River Canyon. Extensive suitable habitat for daytime roosts occurs in the cliffs and canyons of the lava flows east of the CGSA, the region where Zembal, et al. (1978) made their observations.

Several other bat species may occur in the CGSA, but have not yet been collected there.

-- Little brown myotis (Myotis lucifugus).

This species is widely distributed across the northern part of the United States and extends south in California through the Sierra Nevada and San Bernardino Mountains to San Diego County (Hall & Kelson, 1959; WESTEC Services, Inc., 1977). Hall & Kelson (1959) report museum specimens taken at Lone Pine and Keeler in the Owens Valley to the north of the CGSA and in the Argus Range to the east. Because of these nearby records, it seems likely that the little brown myotis at least occasionally may be found in the study area.

-- Yuma myotis (Myotis yumanensis).

The Yuma myotis is a common bat throughout the western United States, especially near bodies of permanent open water (Barbour & Davis, 1969). There are museum records for Carroll Creek near Owens Lake (Patricia Brown, personal communication) and for the Walker Pass area of the southern Sierra Nevada (Hall & Kelson, 1959). Although there seem to be no reports for the mountain ranges of the western

Mohave, it is quite possible that the Yuma myotis occurs in or near the CGSA, particularly along the eastern slopes of the Sierra Nevada.

-- Big brown bat (Eptesicus fuscus).

The big brown bat is found throughout North America in virtually all habitats (Barbour & Davis, 1969). It has been taken at the Junction Ranch on the Naval Weapons Center and at Mountain Springs Canyon in the Argus Range (Patricia Brown, personal communication). Other records exist for the White Mountains, Panamint Mountains, and the Walker Pass area in the Sierra Nevada. The big brown bat utilizes rock crevices, old mines, and buildings as daytime roosts in desert habitats; it is almost certain to occur in the CGSA.

-- Hoary bat (Lasiurus cinereus).

Like the silver-haired bat, this species migrates long distances between winter and summer ranges. The hoary bat is found throughout the Western Hemisphere and records indicate that it is fairly common in the southwestern United States (Barbour & Davis, 1959). There are several museum specimens taken in the northeastern Mohave Desert during spring and fall and a report for the Walker Pass region of Kern County (Patricia Brown, personal communication). Hoary bats might be expected to pass through the CGSA in April and May on their northward migration and again in September on their return to the winter range farther south. They characteristically roost in trees during the day; suitable habitat exists at Coso Junction in Rose Valley and at Haiwee Spring .

-- Spotted bat (Euderma maculatum).

This rare bat is found throughout the interior regions of the western United States south onto the Mexican Plateau (Watkins, 1977). Little is known of its habits and natural history and relatively few specimens have been collected. The spotted bat was listed as a rare species in the Red Data Book (IUCN, 1969), but it is not currently listed as rare, threatened, or endangered by the U. S. Fish & Wildlife Service (USFWS) or by the California Department of Fish & Game (DFG). While spotted bats have been taken in a variety of habitats, from treeless desert and sagebrush plains to montane coniferous forests, they appear to require high cliffs and canyons with rock crevices that can serve as daytime roosts (Easterla, 1973). Three specimens of the spotted bat have been reported from the general region of the northwestern Mohave Desert and Owens Valley. Hall (1939) described a specimen found in Red Rock Canyon, Kern County; and Stager (1957) presented a record from China Lake, San Bernardino County. Recently, a spotted bat was found in Bishop, Inyo County (Constantine, et al., 1979). Although no evidence has yet been found of this species in the CGSA, these records and the existence of suitable habitat in the form of extensive lava cliffs indicate that it may well be present.

-- Mexican free-tailed bat (Tadarida brasiliensis).

This species is found throughout the southern United States. Summer colonies of females and young numbering in the millions occur in caves from Arizona east to Texas and

Oklahoma (Barbour & Davis, 1959). These populations migrate to Mexico in the fall and return the following spring. In the coastal areas of southern California and in the Central Valley and Coast Ranges of northern California, Mexican free-tailed bats occur throughout the year in small colonies, usually in man-made structures. Few records exist for the Mohave Desert; no large colonies are known, but occasional specimens have been collected in widely separated locations. In this area, these bats probably use rock crevices in cliffs as daytime roosts. A Mexican free-tailed bat was taken at Little Lake on March 25, 1918; and more recently specimens are known from the Inyo and Panamint Mountains (Patricia Brown, personal communication). It is likely that the species occurs in small numbers in the CGSA.

For several reasons, this inventory of the bat fauna of the CGSA was not as complete as might have been desired. First, it was not possible to sample at all seasons when bats are active in this area. Because of budget limitations, the bat inventory had to be carried out at the same time as the carnivore and rodent surveys. No special effort could be made to conduct field studies in the spring or in late summer and early fall. Second, it was not possible to sample all parts of the CGSA. Mist netting is most effective at restricted areas of open water where bat activity is concentrated, such as springs and small ponds. No sites appropriate for successful mist net sampling are available in the western and southern portions of the CGSA. Collecting was attempted at Rose Valley Ranch, Little Lake, and in the canyon above Portuguese Bench. No bats were taken because of the lack of suitable conditions for mist netting, although they were seen to be present at all three sites. Third, it was not possible to continue mist net sampling through the night. This can be important because certain species, such as the spotted bat, are most active after midnight (Easterla, 1973). However, since field personnel had to be on duty early in the morning to carry out the carnivore and rodent inventory work, mist netting was usually terminated at about midnight.

Despite these limitations, a great deal of useful data was collected and a number of conclusions seem warranted. The five species that make up the permanent bat fauna of the CGSA are all well-adapted to the desert environment and are probably found throughout the study area. While these species undoubtedly forage widely over flat open habitats, as well as over the more broken and rugged parts of the CGSA, they are dependent on crevices in canyons, cliffs, and steep rocky outcrops for their daytime roosts. These crevices are critical habitat features because they provide protection from predators, shelter against the summer heat, and refuge for undisturbed winter hibernation. Bats seem to be particularly abundant where suitable roosting habitat is located within a mile or two of open water.

The scarcity of surface water and daytime roosting sites over much of the CGSA may, in fact, limit bat abundance and diversity. Areas of the Coso Range to the north and east of the CGSA appear to offer better habitat because of the more rugged terrain, the presence of numerous mines, and the greater frequency of springs and other water sources. Thus, although bats of at least five species are common, the CGSA does not provide unusually valuable or unique habitat for these mammals as compared to other parts of the northwestern Mohave Desert.

There is little risk of adverse impact on the bat fauna as a result of geothermal energy development activities. Bats are generally dispersed during the day in many small groups occupying natural refuges such as crevices in rocky cliffs and canyon walls. These daytime roosting sites are very unlikely to be physically disturbed because they occur in steep inaccessible areas. No large nursery or hibernating colonies of bats have been found in caves, mines, or buildings where they would be subject to disturbance and vandalism as a result of increased human usage of the CGSA. In order to protect the bat populations of the CGSA, it is important to ensure that scarce water sources are not impacted by development. The bat fauna would readily benefit if new permanent water sources were established to compensate for development impacts on other wildlife species.

E. SUMMARY

Fall and summer sampling of bat populations has been carried out by mist netting at seven locations within and adjacent to the CGSA. The permanent bat fauna includes five species: California myotis, small-footed myotis, western pipistrelle, Townsend's big-eared bat, and pallid bat. All are common and widely distributed throughout the California deserts. Two additional species taken only in October 1978 (long-legged myotis and silver-haired bat) are apparently seasonal transients in the region of the CGSA. An eighth species, the western mastiff bat, was reported on the basis of visual observations during an earlier study (Zembal, et al., 1978). Greatest capture success was achieved at Haiwee Spring, where seven of the eight species known from the area were collected. No large bat colonies have been discovered. Bat populations in the CGSA are almost entirely dependent on natural rock crevices for their daytime roosts. The risk of adverse impact from geothermal development seems quite low, since bats are widely dispersed during the day in small groups throughout steep inaccessible terrain. However, water sources should be protected from development impacts.

III. RODENTS

A. INTRODUCTION

This sampling program was designed to inventory the rodent fauna of the Coso Geothermal Study Area (CGSA). Use of a standard live-trapping technique in major habitat types within the CGSA has documented the occurrence and relative abundance of both nocturnal and diurnal rodent species.

These data are of importance for two reasons: (1) rodents are likely to be impacted by construction activities and the resulting loss of habitat during the early stages of geothermal development and (2) the Mohave ground squirrel (Spermophilus mohavensis), listed as a rare mammal under California law, is known to occur in the study area.

B. METHODS

Live-trap sampling sites were carefully chosen to represent the important habitats and to provide wide geographic coverage within the CGSA. These sites were selected to complement rather than duplicate the trapping effort carried out by Zembal, et al. (1978) on Navy fee lands.

The major habitat types inventoried included Creosote Bush Scrub, Saltbush Scrub, and Joshua Tree Woodland. At least one representative site was sampled within each of these major habitat types to evaluate differences between habitats in the distribution and abundance of rodent species. In addition, other trapping sites were selected to obtain maximum geographic coverage and to investigate local variation in the rodent fauna within habitat types.

Trapping was carried out in early summer, from May 30 through July 2, 1979. This season was chosen to ensure the greatest trapping success, since rodent activity is highest in early summer and population levels are at a peak because of the recruitment of young animals. A particularly important consideration was the fact that Mohave ground squirrels are most active and readily trapped at this time.

Live-trapping was chosen as the only sampling technique to be used in this study to minimize the risk of harm to the Mohave ground squirrel. The California Department of Fish and Game requested that no snap-trapping be conducted because this rare mammal was known to occur in the CGSA and is stringently protected by law. All traps used were manufactured by the H. B. Sherman Trap Company and included both the folding and non-folding types with dimensions of 3 x 3.5 x 9 inches.

Nocturnal rodents were trapped at five study sites (Table 1 and Figure 1). These included two sites in Joshua Tree Woodland (Pumice Mine and Volcano Peak) and one in which both Creosote Bush Scrub and Saltbush Scrub habitats were represented (Sugarloaf). Sampling was carried out for three consecutive nights at each site, giving a total trapping effort of 1000 trap-nights. Traps were set in three parallel lines approximately 30 meters apart. One trap was placed every 15 meters along each line. Thus, the area sampled was a belt transect slightly over one mile in length. Bait was a mixture of rolled oats, wild bird seed, and peanut butter. Traps were set late in the afternoon and checked early the following morning. All rodents were identified to species and the sex recorded. Pocket mice (genus Perognathus), deer mice (Peromyscus maniculatus), canyon mice (Peromyscus crinitus), and southern grasshopper mice (Onychomys torridus) were sacrificed, assigned a Bureau of Land Management catalog number, preserved by freezing, and transferred to the Los Angeles County Museum for accession to the Mammal Collection. Five to ten individuals of each sex of all kangaroo rat species (genus Dipodomys) and desert woodrats (Neotoma lepida) were also taken as

TABLE 1. Live-trap sampling sites and trapping effort for nocturnal and diurnal rodents during early summer 1979. See Figures 1 and 2 for locations of trapping sites.

Trapping Site & Date	Habitat Type	Trapping Effort Nocturnal Rodents (trap-nights)	 Diurnal Rodents (trap-days)
ROSE VALLEY May 30-June 1, 1979	Saltbush Scrub	1000	1000
SUGARLOAF June 3-5, 1979	Creosote Bush Scrub/ Saltbush Scrub	1000	666*
SIERRA SLOPE June 7-9, 1979	Creosote Bush Scrub	1000	1000
VOLCANO PEAK June 23-25, 1979	Joshua Tree Woodland	1000	794**
PUMICE MINE June 27-29, 1979	Joshua Tree Woodland	1000	1000
CACTUS PEAK June 30, 1979	Saltbush Scrub		125
1-1/2 MILE SOUTH OF SUGARLOAF July 1, 1979	Saltbush Scrub		125
NWC COSO GATE July 2, 1979	Creosote Bush Scrub		125
	TOTAL	5000	4835

---

* Because of Navy weapons testing operations, trapping could only be conducted for two days at this site.

** Because of Navy weapons testing operations, it was not possible to empty traps of nocturnal rodents and reset them on the morning of June 23; as a result, only 127 traps were available to diurnal rodents.

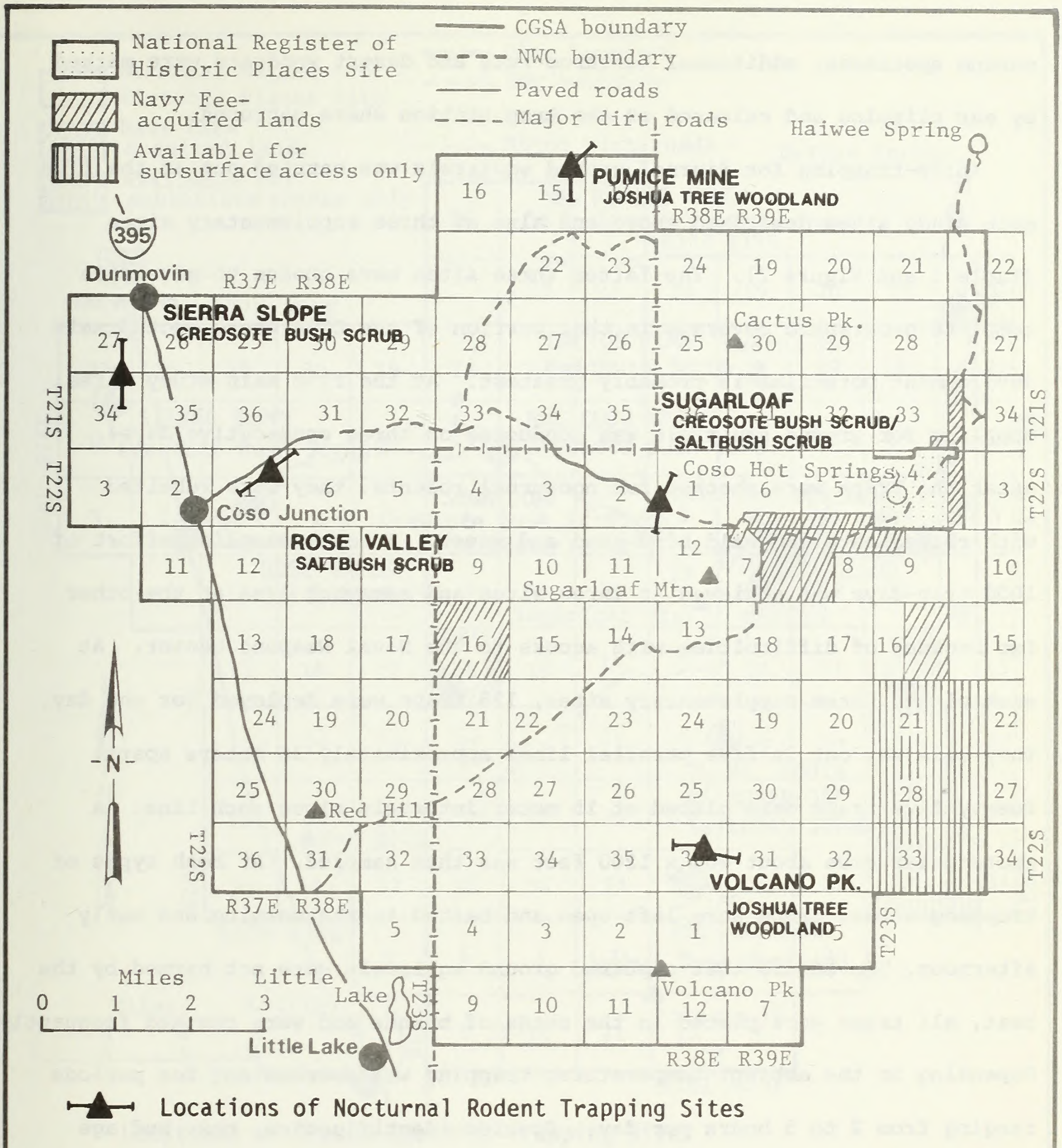


Figure 1. RODENT REPORT

museum specimens; additional kangaroo rats and desert woodrats were marked by ear clipping and released at the trap station where captured.

Live-trapping for diurnal ground squirrels was carried out at the five main study sites described above and also at three supplementary sites (Table 1 and Figure 2). The latter three sites were chosen to give more complete geographic coverage in that portion of the CGSA where geothermal development potential is probably greatest. At the five main study sites, sampling for ground squirrels was conducted on three consecutive days; after the traps were checked for nocturnal rodents, they were rebaited with rolled oats and wild bird seed and reset. A total sampling effort of 1000 trap-days was achieved at three sites and somewhat less at the other two because of difficulties with access to the Naval Weapons Center. At each of the three supplementary sites, 125 traps were deployed for one day. They were set out in five parallel lines approximately 30 meters apart; twenty-five traps were placed at 15 meter intervals along each line. A rectangular area about 400 x 1200 feet was thus sampled. At both types of trapping sites, traps were left open and baited in the morning and early afternoon. To ensure that captured ground squirrels were not harmed by the heat, all traps were placed in the shade of bushes and were checked frequently. Depending on the ambient temperature, trapping was carried out for periods ranging from 2 to 5 hours per day. Species identification, sex, and age (adult or immature) were recorded for all captured ground squirrels. Mohave ground squirrels were photographed, marked with an indelible dye, and released unharmed at the place of capture, while five to ten antelope ground squirrels of each sex were taken as museum specimens from the five main trapping sites.

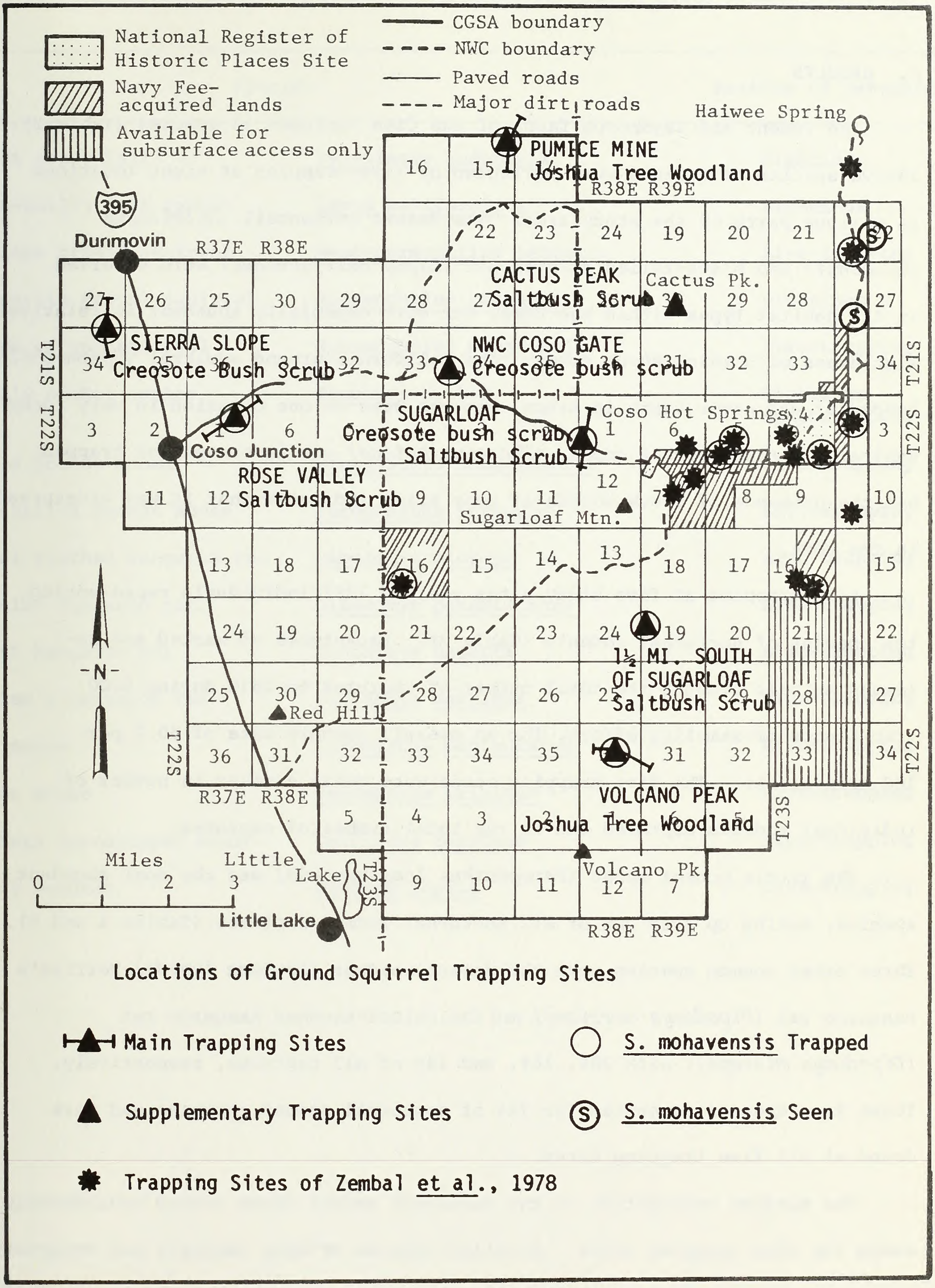


Figure 2. RODENT REPORT

C. RESULTS

The rodent and lagomorph fauna of the CGSA includes 16 species (Table 2). Twelve species of rodents were collected by live-trapping at eight locations in various parts of the study area. The desert cottontail (*Sylvilagus audubonii*) and black-tailed jack rabbit (*Lepus californicus*) were observed in all habitat types within the CGSA, but were especially abundant in relatively flat areas with thick shrub cover. The California ground squirrel (*Spermophilus beecheyi*) was never taken in traps, but was seen on one occasion in very rocky habitat. Botta's pocket gopher (*Thomomys bottae*) was never seen or trapped, but the presence of fresh mounds at many sites indicated that it was widespread in the CGSA.

Live trapping at five study sites yielded 2292 individuals representing ten species of nocturnal rodents (Table 3). Recaptures of marked and released animals brought the total number of captures to 2510 during 5000 trap-nights of sampling effort, for an overall capture rate of 50.2 per 100 trap-nights. The five trapping sites were quite similar in number of individual rodents captured and in the total number of captures.

The little pocket mouse (*Perognathus longimembris*) was the most abundant species, making up over 22% of all nocturnal rodent captures (Tables 4 and 5). Three other common species were the desert woodrat (*Neotoma lepida*), Merriam's kangaroo rat (*Dipodomys merriami*), and the chisel-toothed kangaroo rat (*Dipodomys microps*), with 20%, 16%, and 14% of all captures, respectively. These four species accounted for 72% of nocturnal rodent captures and were found at all five trapping sites.

The species composition of the nocturnal rodent fauna varied considerably among the five trapping sites. Detailed records of daily captures and recaptures

TABLE 2. Rodent and lagomorph fauna of the Coso Geothermal Study Area.

Species		Methods of Detection
Desert cottontail	*Sylvilagus audubonii*	Sightings
Black-tailed jack rabbit	*Lepus californicus*	Sightings
Antelope ground squirrel	*Ammospermophilus leucurus*	Live-trapping
California ground squirrel	*Spermophilus beecheyi*	Sightings
Mohave ground squirrel	*Spermophilus mohavensis*	Live-trapping
Botta's pocket gopher	*Thomomys bottae*	Sightings (gopher mounds)
Little pocket mouse	*Perognathus longimembris*	Live-trapping
Long-tailed pocket mouse	*Perognathus formosus*	Live-trapping
Chisel-toothed kangaroo rat	*Dipodomys microps*	Live-trapping
Panamint kangaroo rat	*Dipodomys panamintinus*	Live-trapping
Desert kangaroo rat	*Dipodomys deserti*	Live-trapping
Merriam's kangaroo rat	*Dipodomys merriami*	Live-trapping
Deer mouse	*Peromyscus maniculatus*	Live-trapping
Canyon mouse	*Peromyscus crinitus*	Live-trapping
Southern grasshopper mouse	*Onychomys torridus*	Live-trapping
Desert woodrat	*Neotoma lepida*	Live-trapping

C. RESULTS

The rodent and lagomorph fauna of the CGSA includes 16 species (Table 2). Twelve species of rodents were collected by live-trapping at eight locations in various parts of the study area. The desert cottontail (*Sylvilagus auduboni*i) and black-tailed jack rabbit (*Lepus californicus*) were observed in all habitat types within the CGSA, but were especially abundant in relatively flat areas with thick shrub cover. The California ground squirrel (*Spermophilus beecheyi*) was never taken in traps, but was seen on one occasion in very rocky habitat. Botta's pocket gopher (*Thomomys bottae*) was never seen or trapped, but the presence of fresh mounds at many sites indicated that it was widespread in the CGSA.

Live trapping at five study sites yielded 2292 individuals representing ten species of nocturnal rodents (Table 3). Recaptures of marked and released animals brought the total number of captures to 2510 during 5000 trap-nights of sampling effort, for an overall capture rate of 50.2 per 100 trap-nights. The five trapping sites were quite similar in number of individual rodents captured and in the total number of captures.

The little pocket mouse (*Perognathus longimembris*) was the most abundant species, making up over 22% of all nocturnal rodent captures (Tables 4 and 5). Three other common species were the desert woodrat (*Neotoma lepida*), Merriam's kangaroo rat (*Dipodomys merriami*), and the chisel-toothed kangaroo rat (*Dipodomys microps*), with 20%, 16%, and 14% of all captures, respectively. These four species accounted for 72% of nocturnal rodent captures and were found at all five trapping sites.

The species composition of the nocturnal rodent fauna varied considerably among the five trapping sites. Detailed records of daily captures and recaptures

TABLE 2. Rodent and lagomorph fauna of the Coso Geothermal Study Area.

Species		Methods of Detection
Desert cottontail	Sylvilagus audubonii	Sightings
Black-tailed jack rabbit	Lepus californicus	Sightings
Antelope ground squirrel	Ammospermophilus leucurus	Live-trapping
California ground squirrel	Spermophilus beecheyi	Sightings
Mohave ground squirrel	Spermophilus mohavensis	Live-trapping
Botta's pocket gopher	Thomomys bottae	Sightings (gopher mounds)
Little pocket mouse	Perognathus longimembris	Live-trapping
Long-tailed pocket mouse	Perognathus formosus	Live-trapping
Chisel-toothed kangaroo rat	Dipodomys microps	Live-trapping
Panamint kangaroo rat	Dipodomys panamintinus	Live-trapping
Desert kangaroo rat	Dipodomys deserti	Live-trapping
Merriam's kangaroo rat	Dipodomys merriami	Live-trapping
Deer mouse	Peromyscus maniculatus	Live-trapping
Canyon mouse	Peromyscus crinitus	Live-trapping
Southern grasshopper mouse	Onychomys torridus	Live-trapping
Desert woodrat	Neotoma lepida	Live-trapping

TABLE 3. Summary of results of live-trapping for nocturnal rodents at five trapping sites in the CGSA.

Trapping Site	Rose Valley	Sugarloaf	Sierra Slope	Volcano Peak	Pumice Mine	Totals
Habitat Type	Saltbush Scrub	Creosote Bush Scrub & Saltbush Scrub	Creosote Bush Scrub	Joshua Tree Woodland	Joshua Tree Woodland	
Number of Species	7	10	7	10	9	10
Number of Invividuals Captured	483	469	424	497	419	2292
Total Number of Captures	508	483	490	513	516	2510
Number of Trap-nights	1000	1000	1000	1000	1000	5000
Number of Captures/100 trap-nights	50.8	48.3	49.0	51.3	51.6	50.2

TABLE 4. The total number of captures of nocturnal rodent species at five trapping sites in the CGSA. Total catch/100 trap-nights can be calculated by dividing each value by 10, since sampling effort totalled 1000 trap-nights at each site.

Species	Rose Valley	Sugarloaf	Sierra Slope	Volcano Peak	Pumice Mine	Totals
Perognathus longimembris	174	205	116	35	29	559
Perognathus formosus		13	45	4	5	67
Dipodomys microps	108	78	53	96	14	349
Dipodomys panamintinus		1		127	82	210
Dipodomys deserti	7	2		11		20
Dipodomys merriami	171	86	115	29	10	411
Peromyscus maniculatus	8	29	27	75	42	181
Peromyscus crinitus		37		13	89	139
Onychomys torridus	24	12	13	30	4	83
Neotoma lepida	16	20	121	93	241	491
TOTALS	508	483	490	513	516	2510

TABLE 5. The relative abundance of nocturnal rodent species at five trapping sites in the CGSA. The proportion of the total catch at each site that was made up by a particular species is represented by a decimal fraction.

Species	Rose Valley	Sugarloaf	Sierra Slope	Volcano Peak	Pumice Mine	Totals
Perognathus longimembris	0.34	0.42	0.24	0.07	0.06	0.22
Perognathus formosus		0.03	0.09	0.01	0.01	0.03
Dipodomys microps	0.21	0.16	0.11	0.19	0.03	0.14
Dipodomys panamintinus		< 0.01		0.25	0.16	0.08
Dipodomys deserti	0.01	< 0.01		0.02		0.01
Dipodomys merriami	0.34	0.18	0.23	0.06	0.02	0.16
Peromyscus maniculatus	0.02	0.06	0.06	0.15	0.08	0.07
Peromyscus crinitus		0.08		0.03	0.17	0.06
Onychomys torridus	0.05	0.02	0.03	0.06	0.01	0.03
Neotoma lepida	0.03	0.04	0.25	0.18	0.47	0.20

by species at each site are given in Tables 6-10; total captures, catch per 100 trap-nights, and relative abundance are summarized by species in Tables 4 and 5. The three or four most abundant species at each site made up more than 75% of all captures. The Rose Valley and Sugarloaf sites were quite similar in that the little pocket mouse, Merriam's kangaroo rat, and chisel-toothed kangaroo rat strongly dominated the fauna. At the Sierra Slope site, these three species were also very important, but the desert woodrat was represented by the greatest number of captures. At the Volcano Peak and Pumice Mine sites a different pattern prevailed, with the Panamint kangaroo rat (*Dipodomys panamintinus)*, desert woodrat, and *Peromyscus* species playing the dominant roles.

A total of 124 Mohave ground squirrels (*Spermophilus mohavensis)* and 264 antelope ground squirrels (*Ammospermophilus leucurus)*were taken during 4835 trap-days at eight trapping sites (Table 11). If recaptures were included, the total catch was 146 Mohave ground squirrels and 351 antelope ground squirrels. Overall capture rates were 3.0 and 7.3 per 100 trap-days, respectively. Antelope ground squirrels were found at all eight locations and were always taken in greater numbers than the Mohave ground squirrels. Only at the Cactus Peak supplementary site did trapping fail to reveal the presence of Mohave ground squirrels.

A comparison of trapping success at the five main study sites showed that the abundance of both ground squirrel species was greatest at the Rose Valley and Sierra Slope locations (Table 12). Capture success was lowest at the Pumice Mine site, while the Sugarloaf and Volcano Peak trapping areas yielded intermediate numbers of both species. The total number of ground

TABLE 6. Summary of nocturnal rodent captures at Rose Valley trapping site (Saltbush Scrub). Sampling effort totaled 1000 trap-nights.

Species		Number Captured (Recaptures)			Total Number of Individuals
		5/30/79	5/31/79	6/1/79	
Little pocket mouse	*Perognathus longimembris*	62	66	46	174
Chisel-toothed kangaroo rat	*Dipodomys microps*	47	39	22	108
Desert kangaroo rat	*Dipodomys deserti*	4	2	1	7
Merriam's kangaroo rat	*Dipodomys merriami*	65	48	58 (25)	146
Deer mouse	*Peromyscus maniculatus*	3	3	2	8
Southern grasshopper mouse	*Onychomys torridus*	12	6	6	24
Desert woodrat	*Neotoma lepida*	7	4	5	16
TOTALS		200	168	140 (25)	483

TABLE 7. Summary of nocturnal rodent captures at Sugarloaf trapping site (Creosote Bush Scrub and Saltbush Scrub). Sampling effort totaled 1000 trap-nights.

Species		Number Captured (Recaptures) 6/3/79	6/4/79	6/5/79	Total Number of Individuals
Little pocket mouse	*Perognathus longimembris*	74	75	56	205
Long-tailed pocket mouse	*Perognathus formosus*	6	3	4	13
Chisel-toothed kangaroo rat	*Dipodomys microps*	41	13	24 (3)	75
Panamint kangaroo rat	*Dipodomys panamintinus*	0	1	0	1
Desert kangaroo rat	*Dipodomys deserti*	1	1	0	2
Merriam's kangaroo rat	*Dipodomys merriami*	41	18	27 (9)	77
Deer mouse	*Peromycus maniculatus*	12	11	6	29
Canyon mouse	*Peromyscus crinitus*	19	9	9	37
Southern grasshopper mouse	*Onychomys torridus*	6	2	4	12
Desert woodrat	*Neotoma lepida*	6	6	8 (2)	18
TOTALS		206	139	138 (14)	469

TABLE 8. Summary of nocturnal rodent captures at Sierra Slope trapping site (Creosote Bush Scrub). Sampling effort totaled 1000 trap-nights.

Species		Number Captured (Recaptures)			Total Number of Individuals
		6/7/79	6/8/79	6/9/79	
Little pocket mouse	*Perognathus longimembris*	31	45	40	116
Long-tailed pocket mouse	*Perognathus formosus*	25	11	9	45
Chisel-toothed kangaroo rat	*Dipodomys microps*	11	14	28 (5)	48
Merriam's kangaroo rat	*Dipodomys merriami*	32	34 (10)	49 (19)	86
Deer mouse	*Peromycus maniculatus*	17	8	2	27
Southern grasshopper mouse	*Onychomys torridus*	4	5	4	13
Desert woodrat	*Neotoma lepida*	31	39 (5)	51 (27)	89
TOTALS		151	156 (15)	183 (51)	424

TABLE 9. Summary of nocturnal rodent captures at Volcano Peak trapping site (Joshua Tree Woodland). Sampling effort totaled 1000 trap-nights.

Species		Number Captured (Recaptures)			Total Number of Individuals
		6/23/79	6/24/79	6/25/79	
Little pocket mouse	Perognathus longimembris	7	16	12	35
Long-tailed pocket mouse	Perognathus formosus	1	0	3	4
Chisel-toothed kangaroo rat	Dipodomys microps	42	34	20 (1)	95
Panamint kangaroo rat	Dipodomys panamintinus	51	33	43 (9)	118
Desert kangaroo rat	Dipodomys deserti	5	4	2	11
Merriam's kangaroo rat	Dipodomys merriami	9	10	10 (1)	28
Deer mouse	Peromycus maniculatus	30	23	22	75
Canyon mouse	Peromyscus crinitus	1	10	2	13
Southern grasshopper mouse	Onychomys torridus	17	9	4	30
Desert woodrat	Neotoma lepida	43	21	29 (5)	88
TOTALS		206	160	147 (16)	497

TABLE 10. Summary of nocturnal rodent captures at Pumice Mine trapping site (Joshua Tree Woodland). Sampling effort totaled 1000 trap-nights.

Species		Number Captured (Recaptures) 6/27/79	6/28/79	6/29/79	Total Number of Individuals
Little pocket mouse	*Perognathus longimembris*	8	15	6	29
Long-tailed pocket mouse	*Perognathus formosus*	1	1	3	5
Chisel-toothed kangaroo rat	*Dipodomys microps*	8	3	3	14
Panamint kangaroo rat	*Dipodomys panamintinus*	31	38 (10)	13 (5)	67
Merriam's kangaroo rat	*Dipodomys merriami*	2	7	1	10
Deer mouse	*Peromycus maniculatus*	23	16	3	42
Canyon mouse	*Peromyscus crinitus*	45	29	15	89
Southern grasshopper mouse	*Onychomys torridus*	1	1	2	4
Desert woodrat	*Neotoma lepida*	71	90 (35)	80 (47)	159
TOTALS		190	200 (45)	126 (52)	419

TABLE 11. Summary of results of live-trapping for ground squirrels at eight trapping sites in the CGSA.

Trapping Site	Antelope Ground Squirrel			Mohave Ground Squirrel		
	Total Number of Individuals Captured	Total Catch	Total Catch/ 100 trap-days	Total Number of Individuals Captured	Total Catch	Total Catch/ 100 trap-days
ROSE VALLEY	98	136	13.6	54	61	6.1
SUGARLOAF	33	37	5.5	19	19	2.9
SIERRA SLOPE	48	81	8.1	29	42	4.2
VOLCANO PEAK	46	50	6.3	13	15	1.9
PUMICE MINE	25	33	3.3	5	5	0.5
CACTUS PEAK	2	2	1.6	0	0	0.0
1-1/2 MI. S. of SUGARLOAF	9	9	7.2	2	2	1.6
NWC COSO GATE	3	3	2.4	2	2	1.6
TOTALS	264	351	7.3	124	146	3.0

TABLE 12. Summary of ground squirrel captures at five main trapping sites. Sampling effort totalled 1000 trap-days at each site, except Sugarloaf (666 trap-days) and Volcano Peak (794 trap-days).

Species		Number Captured (Recaptures)			Total Number Individuals Captured
ROSE VALLEY		5/30/79	5/31/79	6/01/79	
Antelope ground squirrel	*Ammospermophilus leucurus*	36	45 (9)	55 (27)	98
Mohave ground squirrel	*Spermophilus mohavensis*	11	18 (1)	32 (6)	54
SUGARLOAF		6/03/79	6/04/79	6/05/79*	
Antelope ground squirrel	*Ammospermophilus leucurus*	11	26 (4)		33
Mohave ground squirrel	*Spermophilus mohavensis*	8	11		19
SIERRA SLOPE		6/07/79	6/08/79	6/09/79	
Antelope ground squirrel	*Ammospermophilus leucurus*	21	28 (11)	32 (22)	48
Mohave ground squirrel	*Spermophilus mohavensis*	10	13 (3)	19 (10)	29
VOLCANO PEAK		6/23/79**	6/24/79	6/25/79	
Antelope ground squirrel	*Ammospermophilus leucurus*	9	16 (1)	25 (3)	46
Mohave ground squirrel	*Spermophilus mohavensis*	1	5 (1)	9 (1)	13
PUMICE MINE		6/27/79	6/28/79	6/29/79	
Antelope ground squirrel	*Ammospermophilus leucurus*	8	12 (3)	13 (5)	25
Mohave ground squirrel	*Spermophilus mohavensis*	0	2	3	5

---

* Because of Navy weapons testing operations, trapping could only be conducted for two days at this site.

** Because of Navy weapons testing operations, it was not possible to empty traps of nocturnal rodents and reset them on the morning of June 23; as a result, only 127 traps were available to diurnal rodents.

squirrels captured increased steadily with each succeeding day over the three day sampling period. This was true for both species and for all of the five sites. Because of this pattern, the results of one day of sampling (125 trap-days) at the three supplementary sites should be compared to the first day of trapping (333 trap-days)at the main study sites. On this basis, ground squirrel populations at the trapping location 1-1/2 miles south of Sugarloaf were similar to those at Rose Valley, Sugarloaf, or Sierra Slope (Table 13). The other two supplementary sites showed lower abundance of ground squirrels. Capture success at Cactus Peak was very much like that for the first trapping day at Pumice Mine, three miles to the northwest. The results for the site at the NWC Coso Gate were comparable to those for the first day at Sugarloaf, about two miles southeast.

D. DISCUSSION

There have been two previous field investigations of small mammal distribution and abundance in the general region of southwestern Inyo County that includes the CGSA. Matson (1976) carried out trapping studies of rodent populations in 10 different plant associations near Owens Lake, about 15-25 miles north of the CGSA. A detailed inventory of the small mammal fauna on Navy fee lands within the CGSA was conducted recently by Zembal, *et al.*(1978). All 16 species of rodents and lagomorphs documented in the present study were also reported in these two earlier investigations (Table 14).

Lagomorphs

As in the present study, Zembal, *et al.* (1978) found the desert cottontail and black-tailed jack rabbit to be widespread and abundant in the Coso area. We have confirmed their observations that these two species occur in all habitats but appear to be most common on relatively level terrain dominated by Saltbush Scrub and related vegetative associations.

TABLE 13. Summary of ground squirrel captures at three supplementary trapping sites. Sampling effort totalled 125 trap-days at each site.

Species		Total Number of Individuals Captured		
		Cactus Peak 6/30/79	1-1/2 Miles South of Sugarloaf 7/1/79	NWC Coso Gate 7/2/79
Antelope ground squirrel	*Ammospermophilus leucurus*	2	9	3
Mohave ground squirrel	*Spermophilus mohavensis*	0	2	2

TABLE 14. Comparison of rodent and lagomorph species recorded in desert habitats in southwestern Inyo County during three recent field studies.

Species	Field Study		
	Matson (1976)	Zembal, et.al. (1978)	Present Study
Sylvilagus audubonii	not studied	x	x
Lepus californicus	not studied	x	x
Ammospermophilus leucurus	x	x	x
Spermophilus beecheyi	x	x	x
Spermophilus mohavensis		x	x
Thomomys bottae	x		x
Perognathus longimembris	x	x	x
Perognathus formosus	x	x	x
Dipodomys microps	x	x	x
Dipodomys panamintinus	x	x	x
Dipodomys deserti	x	x	x
Dipodomys merriami	x	x	x
Reithrodontomys megalotis	x		
Peromyscus maniculatus	x	x	x
Peromyscus crinitus	x	x	x
Peromyscus boylii	x		
Onychomys torridus	x	x	x
Neotoma lepida	x	x	x

Ground Squirrels

Antelope ground squirrels were found to be present in virtually all desert habitats during these three studies (Matson, 1976; Zembal, *et.al.*, 1978; present study, Table 11). However, the CGSA is apparently near the northwest limit of the range of the Mohave ground squirrel. Hoyt (1973) reported a museum specimen from "Haiwee Meadows", presumably just north of the CGSA, while two specimens were recorded from Little Lake. Both the present study and that of Zembal, *et.al.*, (1978) were successful in demonstrating the presence of Mohave ground squirrels in a number of habitats within the CGSA. However, extensive field observations and trapping for small mammals in the vicinity of Owens Lake for three years yielded no evidence of Mohave ground squirrels (Matson, 1976). The California ground squirrel was not observed in the CGSA by Zembal, *et.al.* (1978), but Matson (1976) reported this species to be common in very rocky areas on the higher alluvial slopes west of Owens Lake. We did not see it in the Sierra Slope trapping site, but a colony was found in a granite outcrop area just south of the Pumice Mine trapping site in the Coso Range. California ground squirrels occur in similar rocky habitats east into the Argus Range (K.H. Berry, personal communication).

Pocket Gopher

We have found Botta's pocket gopher in all habitat types, within the CGSA; it seems particularly abundant in the valley floors and basins where the soils included a high proportion of fine materials. Hall and Kelson (1959) give a number of locality records for this species in southwestern Inyo County, including the Argus Range, Owens Lake, "Haway Meadows", and Coso. It was observed recently to be active in the Owens Lake area (Matson, 1976), although Zembal, *et.al.* (1978) did not find it in the CGSA during their field studies.

Nocturnal Rodents

Matson (1976) reported taking the western harvest mouse (*Reithrodontomys megalotis)* and brush mouse (*Peromyscus boylii)* in desert habitats near Owens Lake. These two species are generally found in more mesic environments; the few specimens collected were evidently transient animals that had dispersed from nearby riparian habitats. Neither would be expected as a regular component of the desert rodent fauna in this region. They were not found in the CGSA, even in the isolated riparian habitat at Haiwee Spring (Zembal, *et al.,* 1978).

All three studies have indicated that the nocturnal rodent fauna of desert habitats in the CGSA and adjacent areas consists of ten species: two species of *Perognathus,* four *Dipodomys,* two *Peromyscus,* plus *Onychomys torridus* and *Neotoma lepida.* They are all widely distributed throughout the northwestern Mohave Desert in appropriate habitats (Hall & Kelson, 1959). As many as seven or eight of the ten species have been taken together at the same trapping site in previous studies (Matson, 1976; Zembal, *et al.,* 1978). We have captured all ten nocturnal rodents at the Sugarloaf and Volcano Peak trapping sites (Tables 7 and 9). Brown (1973) has pointed out that rodent communities are characteristically diverse in North American desert and semi-desert habitats and that it is not uncommon to find 8 or 10 species coexisting at a single study site.

A striking result of the present study was the great number of nocturnal rodents taken at all five main trapping sites. In spite of the fact that many captured individuals were removed as museum specimens, the overall capture rate was 50.2/100 trap-nights. In contrast, Matson (1976) recorded an average capture rate for nocturnal rodents of 2.8/100 trap-nights at 10 trapping sites in desert habitats near Owens Lake during summer 1971. Only 152 animals were collected with a sampling effort of 5400 trap-nights. Zembal, *et al.*, (1978) took 488 nocturnal rodents during a total of 3430 trap-nights within the CGSA in summer 1978, for a capture rate of 14.2/100 trap-nights. It would be tempting to interpret these data as indicating that nocturnal rodent populations were at very high levels in summer 1979. However, different sampling methodologies make it virtually impossible to draw valid conclusions. In both previous investigations, trapping effort was concentrated in relatively small areas; thus, these areas were saturated with traps relative to the total number of resident animals at risk of being captured. Even if rodent population densities had been identical to those at the trapping sites sampled in the present study, this would necessarily have resulted in lower capture rates. In view of the fact that these three studies were not designed to estimate population densities, it is inappropriate to speculate about temporal trends in nocturnal rodent abundance.

E. STATUS OF MOHAVE GROUND SQUIRREL

The status of the Mohave ground squirrel within the CGSA is of special concern since this species has been officially designated as Rare by the California Fish and Game Commission (California Department of Fish and Game, 1978). This designation is applied to species that are not presently threatened with extinction, but that occur in such small numbers throughout their range that they may become endangered if environmental conditions worsen. It provides protection in that the taking, possession, and sale of these species is prohibited under penalty of state law.

The historic range of the Mohave ground squirrel was thought to be very limited, covering only a restricted portion of the western Mohave Desert (Hall

& Kelson, 1959). There has been an apparent decline and even extirpation of some local populations and there is evidence of possibly significant habitat loss in some areas due to urban and agricultural development (Hoyt, 1973; Wessman, 1977). For the most part, these changes have been observed along the southern margin of the Mohave ground squirrel's range.

Trapping studies conducted in 1974 and 1975 in eastern Kern and northwestern San Bernardino Counties indicated that this species was still present over large areas of the western Mohave Desert (Wessman & Berry, in press). Additional surveys in 1977 extended the known range to include about 1800 mi^2 of desert habitat north and east of Barstow (Wessman, 1977). Thirty-seven Mohave ground squirrels were collected here and in the southeastern portion of the range during a sampling effort that included over 16,000 trap-days.

Zembal, et al. (1978) identified a total of 35 individuals at a number of sites within the CGSA. Thirteen Mohave ground squirrels were taken with 1759 trap-days and 22 were documented through sightings. The locations of their trapping sites are shown in Figure 2. They reported the species from a variety of habitats, including Saltbush Scrub and Creosote Bush Scrub, with highest apparent abundance in an area on the eastern side of Rose Valley dominated by saltbush species. Although Mohave ground squirrels did not appear to be restricted to particular vegetation types or geographic areas within the portions of the CGSA that they studied, Zembal, et al. (1978) did state that these animals very rarely occurred in steeply-sloping or rocky terrain.

The results of the present study confirm the findings of Zembal, et al. (1978), that the Mohave ground squirrel is widely distributed throughout the CGSA in a number of habitats. With the exception of two sightings along the road north from Coso Hot Springs to Haiwee Spring (Figure 2), our data pertain to areas of the CGSA that were not sampled in the 1978 study. We have documented the occurrence of Mohave ground squirrels in Joshua Tree Woodland sites at the northern and southern edges of the study area (Volcano Peak, Pumice Mine) and in two Creosote Bush Scrub locations on alluvial fans, one on the east slope of the Sierra Nevada (Sierra Slope) and one on the west slope of the Coso Range (NWC Coso Gate). Other sites include the Saltbush Scrub on the floor of Rose Valley and the basins and flats within the Coso Range (Sugarloaf, 1-½ mile south of Sugarloaf). While we did not sample extensively in steep or rocky habitats, we did not see or capture Mohave ground squirrels in these areas; thus, our data agree with those of Zembal, et al. (1978) on this topic.

Other investigators have generally found Mohave ground squirrels difficult to capture; numbers of individuals taken have been very low (Hoyt, 1973; Wessman, 1977; Zembal, et al., 1978). The present study has resulted in the capture of more Mohave ground squirrels than have been reported in all recently published surveys taken together. This was not necessarily due to unusually high population densities at our trapping sites, although that may have been a factor, especially at the Rose Valley, Sugarloaf, and Sierra Slope locations (Table 11). At the five main trapping sites, traps were deployed to sample a considerably larger area than in previous studies and trapping was continued for three days (except Sugarloaf). Table 12 clearly indicates that the total catch increased steadily each day, largely as a result of the capture of new individuals. Even on the last day, significant numbers of new Mohave ground squirrels entered the traps. In previous surveys, sampling effort was usually stopped on the first day that one or more animals were taken. If this had been done in the present study, only 36 Mohave squirrels would have been captured in 1834 trap-days. It seems clear that any attempt to estimate population densities by a mark-recapture method will require 3-6 days of trapping over a relatively large study site (20-40 acres).

In summary, the CGSA supports Mohave ground squirrel populations that are at least as abundant as any recorded to date. Since the species has been trapped at 14 sites within this relatively small area and occurs in almost all habitats, it will be very difficult to carry out geothermal exploration and development activities without causing some adverse impacts. This is particularly true because the areas of relatively level terrain favored by these animals are also the best sites for geothermal facilities. Development impacts can be mitigated to some extent by careful project planning to minimize land use requirements and by prompt revegetation of disturbed areas to the maximum extent feasible. Zembal, _et_ _al_. (1978) have shown that Joshua tree fruits (when available) are a heavily utilized food source; destruction of Joshua trees should therefore be strictly avoided during development. Revegetation programs should include other native plants that are known to be important to Mohave ground squirrels, such as _Lycium_, _Amsinckia_, and _Coreopsis_ (Recht, 1977). Finally, there is the possibility that geothermal development organizations could be required to compensate for unavoidable loss of Mohave ground squirrel habitat by sponsoring off-site habitat improvement or acquisition programs to benefit other wildlife species of concern.

F. SUMMARY

The rodent and lagomorph fauna of the CGSA includes 16 species. The desert cottontail and black-tailed jack rabbit are commonly observed in all habitat types. The California ground squirrel and Botta's pocket gopher were recorded for the first time in the CGSA. Live-trapping at five study sites yielded 2292 individuals representing 10 species of nocturnal rodents. Four species made up over 72% of all captures: little pocket mouse, desert woodrat, Merriam's kangaroo rat, and chisel-toothed kangaroo rat. The five trapping sites were quite similar in total number of nocturnal rodent captures. The two Joshua Tree Woodland sites showed a higher relative abundance of the Panamint kangaroo rat, desert woodrat, and _Peromyscus_ species, while the little pocket mouse, Merriam's kangaroo rat, and chisel-toothed kangaroo rat were the dominant species at the other locations. Live-trapping for ground squirrels was carried out at eight sites in the three habitat types. Antelope ground squirrels were taken in good numbers at all sites. The Mohave ground squirrel, a species officially designated as Rare by the California Fish and Game Commission, was found at seven of the eight sampling sites. A total of 124 individuals were captured; the species was found to be widely distributed through virtually all habitats in the CGSA. Some habitat loss will be unavoidable if geothermal development proceeds in the CGSA.

IV. CARNIVORES

A. INTRODUCTION

This sampling program was designed to inventory the carnivore fauna of the Coso Geothermal Study Area (CGSA). The presence of various carnivore species was determined by identification of tracks left in fine dust spread at more than 100 scent stations throughout the CGSA.

B. METHODS

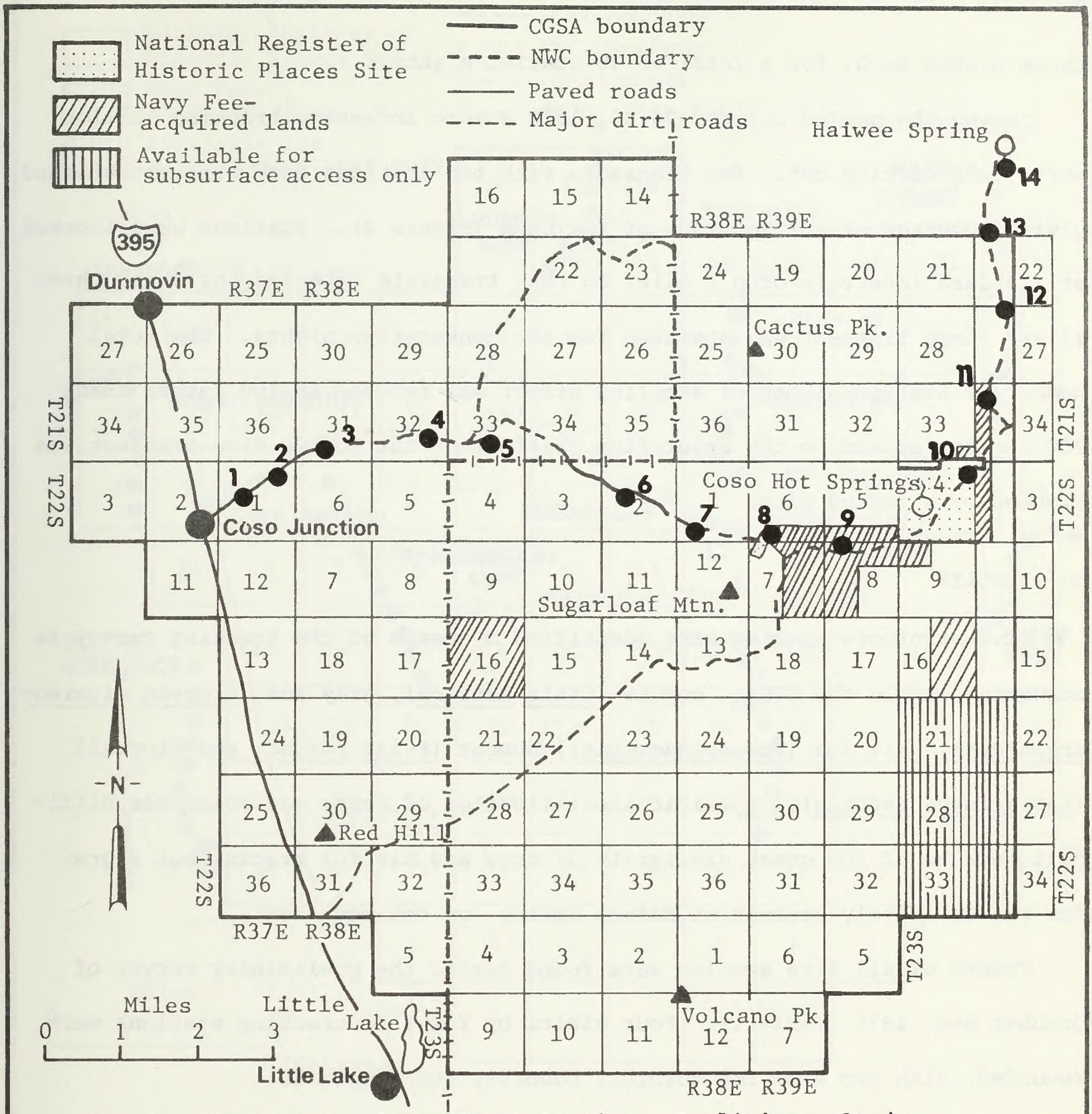
Since carnivores may avoid areas disturbed by geothermal development activities, these animals could effectively suffer significant loss of hunting habitat. Therefore, it is important to document baseline conditions prior to development, identifying areas that may be heavily utilized by carnivores and establishing the occurrence of any species that may be of special concern.

Carnivores generally have large home ranges and often travel through a variety of habitats in search of prey. Because of this, the sampling effort was directed at obtaining relatively complete geographic coverage within the CGSA, rather than at determining carnivore usage of particular habitats.

The technique used to document the presence of various carnivore species in the CGSA was a modification of the scent post method used by the U. S. Fish and Wildlife Service in the Annual Western Predator Survey. Stations were established at intervals along roads within the study area. At each station a 50-pound bag of fire clay was emptied on a smooth, open piece of ground and the fine material spread with a brush in a thin layer over a roughly circular area about 4 feet in diameter. At the center a wooden stake was driven into the ground; canned dogfood was smeared on the stake as an attractant to carnivores. The stations were checked in the morning and any carnivore footprints in the fire clay were identified to species where possible and recorded. No attempt was made to determine the number of individuals of each species that visited a given tracking station; the only data noted were the identity of the species that had been present. The surface of the fire clay was brushed smooth after each inspection.

It is important to recognize that this sampling technique does not provide an estimate or index of the number of individuals of a particular carnivore species in a particular area. The data recorded are simply the number of visits by a species to the artificial tracking stations. A single visit is defined as one or more tracks of a species at a station; therefore, only one visit per species per station per night can be counted. The number of individuals responsible for a given number of visits cannot be determined. For example, five recorded coyote visits to the ten stations on a transect over two nights may be due to only one individual or to five. Since carnivore species probably differ greatly (in unknown ways) in their response to the tracking stations, the number of visits by different species cannot be compared to give indices of relative abundance. All that can be concluded from one or more visits is that the species is present in that part of the CGSA. However, the absence of visits by a carnivore species does not necessarily indicate that it is not present; for example, coyotes have been observed during the day near transects at which no nocturnal coyote visits were recorded.

A preliminary tracking station survey was performed from October 6 to 8, 1978. Fifteen stations were set up at intervals of 0.5 to 2.0 mi. along the road east from Coso Junction to the vicinity of Coso Hot Springs and then north to Haiwee Spring (Figure 1). These stations were operated from one to



● Locations of Carnivore Track Stations, Preliminary Study October 6-8, 1978

Station 15, not shown on map, was located in Section 2, T22S, R39E, east of Coso Hot Springs.

Figure 1. CARNIVORE REPORT

three nights each, for a total of 38 station-nights.

During the period October 24-29, 1978 a more intensive tracking station survey was carried out. Ten transects with ten stations each were established, giving coverage of all sections of the CGSA (Figure 2). Stations were located at standard intervals of 0.3 mile, so that transects extended for about three miles. Each transect was operated for two consecutive nights. The total number of station-nights of sampling effort was reduced to 190 rather than 200 because access to the upper five stations on the Pumice Mine transect was blocked by a locked gate.

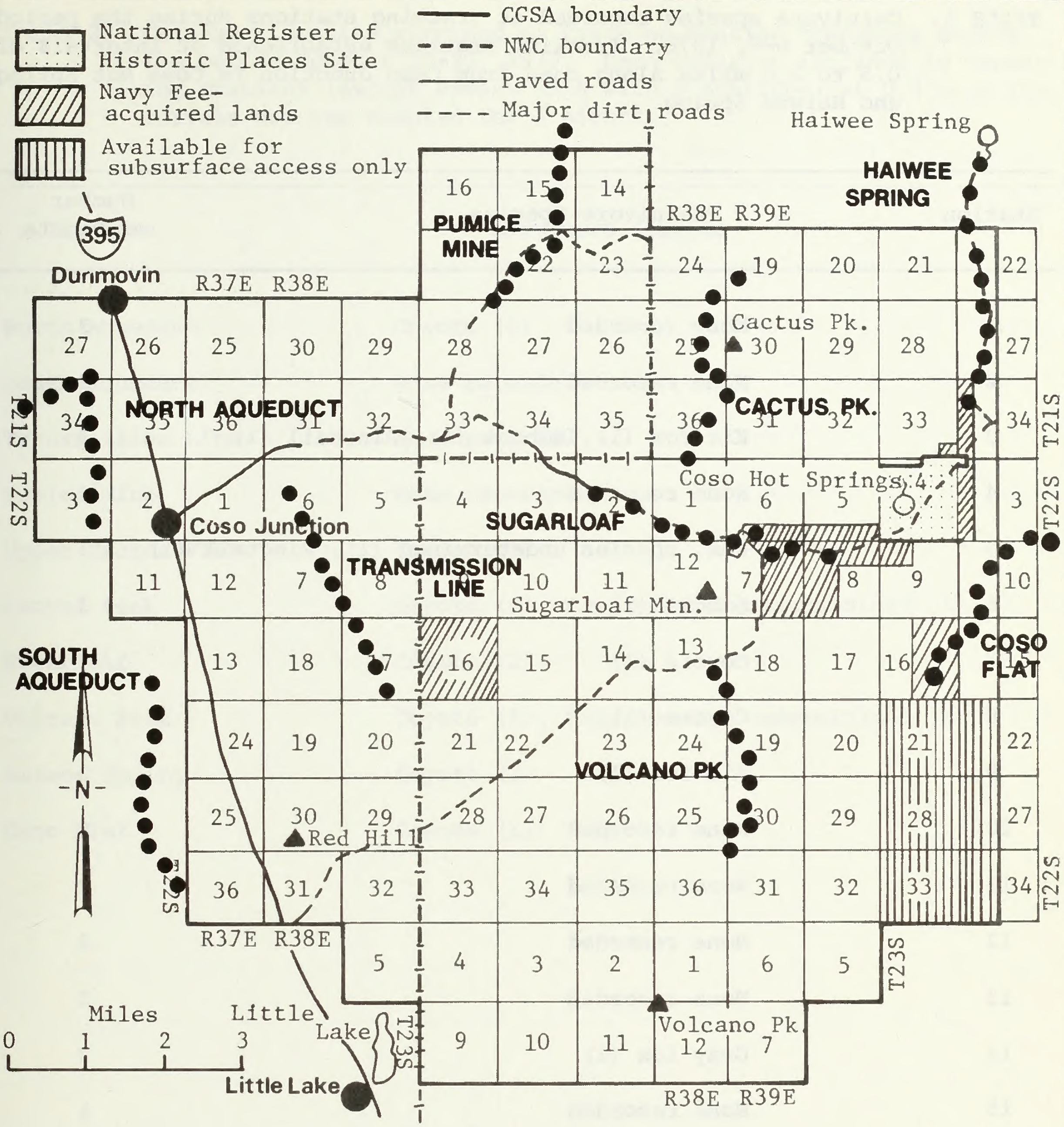
C. RESULTS

Five carnivore species were identified by means of the tracking survey as occurring within the CGSA: coyote (Canis latrans), gray fox (Urocyon cinereoargenteus), kit fox (Vulpes macrotis), bobcat (Felis rufus), and ringtail (Bassariscus astutus). Specific identification of foxes was sometimes difficult because of the great similarity of gray and kit fox tracks, but a gray fox was definitely present at Haiwee Spring on one occasion.

Tracks of all five species were found during the preliminary survey of October 6-8, 1978 (Table 1). Four visits by foxes to tracking stations were recorded, with two each for coyotes, bobcats, and ringtails.

During the second survey period (October 24-29, 1978) only coyotes and foxes were identified as visiting the tracking stations (Table 2). The dominant carnivore species was the coyote, with twelve visits recorded. Fox tracks were observed twice, but no evidence of bobcat or ringtail visits was found.

Coyotes were observed several times during the day in various parts of the CGSA and their calls were heard at night near Haiwee Spring. In June



● Locations of Carnivore Track Stations, Intensive Study October 24-29, 1978

The 10th series of track stations, not shown on map, was in Upper Cactus Flat, just north of the CGSA.

Figure 2. CARNIVORE REPORT

TABLE 1. Carnivore species recorded at tracking stations during the period October 6-8, 1978. Tracking stations established at intervals of 0.5 to 2.0 miles along road from Coso Junction to Coso Hot Springs and Haiwee Spring

Station	Carnivore Species	Number of Nights
1	None recorded	3
2	None recorded	3
3	Kit fox (1), Bobcat (1), Ringtail (1)	3
4	None recorded	3
5	Fox, species undetermined (1), Ringtail (1)	3
6	Bobcat (1)	3
7	Coyote (1)	3
8	Coyote (1)	3
9	Kit fox (1)	3
10	None recorded	2
11	None recorded	2
12	None recorded	2
13	None recorded	2
14	Gray fox (1)	2
15	None recorded	1

TABLE 2. Carnivore species recorded on tracking station transects during the period October 24-29, 1978. Each transect included 10 tracking stations (except Pumice Mine with 5 stations) at 0.3 mile intervals and was sampled for 2 nights.

Transect	Carnivore Species
North Aqueduct	Coyote (1)
South Aqueduct	None recorded
Transmission Line	None recorded
Pumice Mine	None recorded
Upper Cactus Flat	Coyote (2)
Cactus Peak	Coyote (4), Fox, species undetermined (1)
Sugarloaf	Coyote (2)
Volcano Peak	Coyote (1), Fox, species undetermined (1)
Haiwee Spring	Coyote (1)
Coso Flat	Coyote (1)

1979 an active kit fox den was found about one mile west of Sugarloaf Mountain. Two adult and four juvenile kit foxes were seen at the den. Although no direct evidence of mountain lions (Felis concolor) was detected during the carnivore surveys or subsequent field studies in early summer 1979, two independent reports by other observers indicate that they occur in Joshua Tree Woodland in the northern portion of the CGSA. Richard Zembal (Biology Department, California State University, Long Beach) saw a mountain lion in winter 1978 near a pumice mine in Section 15, Township 21 South, Range 38 East (personal communication, September 21, 1978). In February 1979 Clifton Overby, superintendent of the pumice mine in Section 23, Township 21 South, Range 38 East, also saw a mountain lion (personal communication, June 1, 1979). These sightings were within one or two miles of each other and both involved animals described as "small"or "subadult".

D. DISCUSSION

On the basis of all available data, eight species of carnivores are found within the CGSA (Table 3). Field studies by Zembal, *et al.* (1978) in this area confirm the presence of coyotes, kit foxes and bobcats through occasional sightings. These investigators also observed badgers (*Taxidea taxus*), a species that was not detected in the tracking station surveys of October 1978. Zembal, *et al.* (1978) established the presence of the long-tailed weasel (*Mustela frenata*) on the basis of scats and skeletal remains from within and near the CGSA.

Coyote

The coyote is an adaptable, highly successful predator throughout North America (Bekoff, 1977). It is found in all parts of the CGSA and in all habitats; coyotes seem to be the most abundant carnivores in the region. There have been no systematic studies of coyote ecology in the Mohave Desert.

TABLE 3. Carnivore fauna of the Coso Geothermal Study Area

Species		Methods of Detection
Coyote	*Canis latrans*	Tracking stations, sightings
Kit fox	*Vulpes macrotis*	Tracking stations, sightings
Gray fox	*Urocyon cinereoargenteus*	Tracking stations
Ringtail	*Bassariscus astutus*	Tracking stations
Long-tailed weasel	*Mustela frenata*	Skeletal remains, scat (Zembal, *et al.*, 1978)
Badger	*Taxidea taxus*	Sightings (Zembal, *et al.*, 1978)
Mountain lion	*Felis concolor*	Sightings
Bobcat	*Felis rufus*	Tracking stations, sightings

Studies of food habits elsewhere indicate that coyotes are opportunistic, taking a varied diet that includes a wide range of animal and plant materials (Gipson, 1974; Hawthorne, 1972). Rabbits and rodents probably form a large part of the food of coyotes in the CGSA. Home ranges as established in studies in Minnesota, Wyoming, Alberta, and Arkansas vary from 3 to 17 mi^2, with males occupying significantly larger areas (Chesness & Bremicker, 1974; Camenzind, 1974; Nellis & Keith, 1976; Gipson & Sealander, 1972). It is likely that 0.5-1.0 per mi^2 would be a reasonable estimate of population densities over much of the coyote's range (Knowlton, 1972). Whether this would apply to the CGSA is not known.

Kit Fox

Kit foxes are typically found in flat, open, arid to semi-arid habitats. They occur throughout the CGSA, from Rose Valley through the Coso Range to the area of Coso Hot Springs. No life history or ecological studies have been published for the kit fox in the California deserts. Kit foxes in the San Joaquin Valley of California and in Utah are known to prey largely on kangaroo rats and rabbits (Egoscue, 1962; Laughrin, 1970; Morrell, 1972) and this species presumably does so in the CGSA as well. Morrell (1972) has indicated that individual San Joaquin kit foxes (*Vulpes macrotis mutica*) may remain within a 1-2 mi^2 area throughout their lives. Observations on kit foxes in desert habitats have shown that they hunt up to three miles from their home dens (Grinnell, *et al.*, 1937; Egoscue, 1962). Population density estimates for western Utah ranged from a maximum of two adult kit foxes / 1 mi^2 to one adult / 4 mi^2 during a decline in black-tailed jack rabbit abundance (Egoscue, 1962 & 1975). The San Joaquin kit fox has been reported to show densities of one to six adults / 1 mi^2 over the entire range of the subspecies (Laughrin, 1970; Morrell, 1972 & 1975).

The status of California desert populations of the kit fox is largely unknown. Other California subspecies have been severely affected by human activities. Coastal populations in southern California (V. m. macrotis) were apparently extirpated decades ago (Grinnell, et al., 1937). San Joaquin Valley populations (V. m. mutica) have suffered extensive reductions in range as a result of conversion of native habitat to agricultural, residential, and industrial land uses (Morrell, 1975). This subspecies is now listed as Endangered by the U. S. Department of Interior (1976) and Rare by the California Department of Fish and Game (1978). While the extent of kit fox habitat loss has not been as extreme in the California deserts as in coastal southern California and the San Joaquin Valley, similar adverse changes have occurred in certain areas. The CGSA supports a viable kit fox population largely unaffected by present land uses.

Gray Fox

The tracking station survey revealed the presence of the gray fox, a species not previously reported from the region of the CGSA. A set of footprints identified as those of a gray fox on the basis of length of stride were recorded at Haiwee Springs. The extensive riparian willow growth here should provide excellent habitat for this species. Gray foxes have been taken in the Inyo and White Mountains to the north of the CGSA (Hall & Kelson, 1959). Populations are also known to exist in a number of desert mountain ranges in Riverside and Imperial Counties; observations of gray foxes have not infrequently been made near springs (WESTEC Services, Inc., 1977). It is likely that gray foxes are restricted to the vicinity of Haiwee Spring, where willow brush and rocky broken habitat are available, and that the species is not widely distributed within the CGSA.

Ringtail

Although the ringtail typically occurs in coastal and foothill chaparral in California, it is also found in many desert mountain ranges (Johnson, et al., 1948; Hall & Kelson, 1959; WESTEC Services, Inc., 1977). Ringtails were shown for the first time to be present in the CGSA as a result of footprints recorded at two tracking stations in the hills on the east side of Rose Valley. One station was located adjacent to a steep hillside covered with large granite boulders, while the other was in a dry wash some distance from any rocky outcrops. Ringtails are probably distributed throughout the CGSA where suitable cover in the form of cliffs and rocky hillsides is available. No ecological data are available for ringtails in the California deserts, but Trapp (1978) reported mean home ranges as determined by radiotracking to be about 350 acres for a population in Zion Canyon, Utah. Ringtail population densities were estimated at about 7.6 per mi^2 in the fall when juveniles range with their parents. Food habits data indicated that small mammals such as Peromyscus and Neotoma were the most important component of the diet in the Zion Canyon ringtails. It seems likely that these findings would apply in general to ringtail populations in the CGSA. This species is fully protected under California law.

Long-tailed Weasel

Long-tailed weasels have not been recorded over much of the desert area of California and southern Nevada (Hall & Kelson, 1959). However, specimens have been taken in the Owens Valley about 35-50 miles to the north of the CGSA and south through the Sierra Nevada to Kern County. The skeletal remains reported by Zembal et al. (1978) from a site about seven miles NNE of Coso Hot Springs indicate that the long-tailed weasel is very likely to occur within the CGSA. Since this species is difficult to trap and does not readily visit tracking stations, its presence would not be easy to document.

Badger

No data appear to be available on the status of badger populations in the desert regions of California. It is reasonable to assume that ground squirrels, pocket gophers and other rodents make up the bulk of their diet in the CGSA, just as in other parts of their range (Snead and Hendrickson, 1942). Badgers may travel over large areas; a recent radiotracking study in Minnesota indicated that a single female had an overall home range of 2100 acres, although only a small portion of this area was used in fall and winter (Sargeant and Warner, 1972). While nothing is known of badger habitat preferences within the CGSA, it seems likely that most activity would be concentrated in areas with high rodent populations.

Mountain Lion

Mountain lions are known to be resident in the Inyo and Panamint Mountains, especially in Pinyon-Juniper Woodland, and have been reported previously from the Argus and Coso Ranges (Richard Weaver, personal communication, July 13, 1979). It is entirely possible that a small resident mountain lion population may utilize at least a portion of the CGSA, since a variety of prey items are available here, including deer, burros, rabbits and rodents. However, since the two recent observations apparently involved subadult individuals present in winter, they may have been transients from the Sierra Nevada or neighboring desert mountain ranges. In either case, the number of mountain lions present must be quite low, as radiotracking studies in optimum habitat in the central California Coast Range indicate home ranges up to 100 mi^2 in males and non-breeding females (Larry Sitton, personal communication, April 21, 1979).

Bobcat

Little is known of the ecology and natural history of the bobcat in the California deserts. The species has a wide geographical and elevational distribution throughout the region east of the Sierra Nevada (Hall & Kelson, 1959). Bobcats in Joshua Tree National Monument typically find cover in rocky, broken terrain and hunt out over the more open alluvial fans and basins, often up to several miles from den areas (David Zezulak, personal communication, April 21, 1979). Home ranges in Joshua Tree

National Monument have been estimated at 4-6 $mi.^2$ Bobcats there feed primarily on rabbits and woodrats. Although only two visits to tracking stations were recorded in the course of this study, with a single sighting reported by Zembal, et al. (1978), the bobcat undoubtedly utilizes all habitats within the CGSA.

E. SUMMARY

Eight carnivore species are found in the CGSA. These include the coyote, kit fox, and bobcat, which are known from sightings and the tracking station survey to be widely distributed through a variety of habitats. The gray fox was recorded at one tracking station near Haiwee Spring and is probably restricted to the riparian habitat and rocky canyons in that area. The ringtail, a species fully protected under California law, was documented at two tracking stations in the hills on the east side of Rose Valley. Ringtails probably occur in steep, rocky terrain throughout the CGSA. Badgers have been sighted in the vicinity of Coso Hot Springs and mountain lions in Joshua Tree Woodland on the northern edge of the CGSA. Finally, there is evidence that the long-tailed weasel is found in the Coso Range.

V. RARE, THREATENED AND ENDANGERED SPECIES: SUMMARY

No threatned or endangered mammal species are known to exist in or immediately near the study area. One species designated Rare (by the California Fish and Game Commission) is found widely throughout the CGSA, however: the Mohave Ground Squirrel (Spermophilus mohavensis). The status of this species is discussed above in Section III passim, and in more detail on pages 42-45.

Known and probable bat fauna of the CGSA (both permanent and transient) include no listed species. The spotted bat (Euderma maculatum) -- a relatively rare species, though not currently listed by USFWS or DFG -- has been reported from nearby areas and suitable habitat for the species exists within the CGSA. See page 14 for further discussion.

No rare or endangered carnivores are known to exist within the CGSA. The ringtailed cat, or ringtail, however (Bassariscus astutus) is fully protected under California law; tracks of this species were recorded during the present study (see pages 50 and 57-58). The status of California desert populations of the kit fox (Vulpes macrotis) is undetermined; the San Joaquin Valley subspecies is presently on the USDI Endangered list, and is designated Rare by California DFG. While habitat loss in desert areas has not been as severe as in other areas, some adverse changes have occurred. The CGSA presently offers excellent habitat for this species (see pages 56-57).

VI. LITERATURE CITED

A. BATS

Barbour, R.W. and W.H. Davis. 1969. Bats of America. The University Press of Kentucky, Lexington, Kentucky.

Constantine, D.G., G.L. Humphrey, and T.B. Herbenick. 1979. Rabies in Myotis thysanodes, Lasiurus ega, Euderma maculatum, and Eumops perotis in California. Jour. Wildl. Diseases, 15:343-345.

Easterla, D.A. 1973. Ecology of the 18 species of Chiroptera at Big Bend National Park, Texas. Northwest Missouri State Univ. Studies, 34:1-165.

Eger, J.L. 1977. Systematics of the genus Eumops (Chiroptera: Molossidae). Life Sci. Contr., R. Ont. Mus., Number 110.

Hall, E.R. 1939. The spotted bat in Kern County, California. Jour. Mammal., 20:103.

Hall, E.R. and K.R. Kelson. 1959. The Mammals of North America. The Ronald Press, New York.

IUCN (International Union for the Conservation of Nature). 1969. Red Data Book. Vol. 1. Mammalia. MA/34/Euder/mac.

Krutzsch, P.H. 1955. Observations on the California mastiff bat. Jour. Mammal., 36:407-414.

Stager, K.E. 1957. Records of the spotted bat from California and Arizona. Jour. Mammal., 38:260.

Vaughan, T.A. 1959. Functional morphology of three bats: Eumops, Myotis, Macrotus. Univ. Kansas Publ., Mus. Nat. Hist., 12:1-153.

Watkins, L.C. 1977. Euderma maculatum. Mammalian Species, No. 77, pp. 1-4.

WESTEC Services, Inc. 1977. Survey of Chiroptera and Carnivora in Imperial, Riverside, and San Diego Counties. Final Report, Contract No. YA-512-CT6-274. Submitted to Bureau of Land Management, Riverside District, California.

Zembal, R., C. Gall, D. Kruska, and P. Lobnitz. 1978. An inventory of the vascular plants and small mammals of the Coso Hot Springs Area of Inyo County, California. Submitted to Naval Weapons Center, China Lake, California.

B. RODENTS

Brown, J.H. 1973. Species diversity of seed-eating desert rodents in sand dune habitats. Ecology, 54:775-787.

California Department of Fish & Game. 1978. At the crossroads 1978--A report on California's endangered and rare fish and wildlife. California Department of Fish & Game, Sacramento, California.

Hall, E.R. and K.R. Kelson. 1959. The mammals of North America. Ronald Press, New York.

Hoyt, D.F. 1973. Mohave ground squirrel survey, 1972. Calif. Dept. Fish & Game, Spec. Wildl. Invest. Final Rep., Proj. W-54-R, Job II-5.5.

Matson, J.O. 1976. The distribution of rodents in Owens Lake region, Inyo County, California. Contrib. in Sci., Nat. Hist. Mus. Los Angeles Co., No. 276.

Recht, M.A. 1977. The biology of the Mohave ground squirrel, Spermophilus mohavensis; home range, daily activity, foraging and weight gain, and thermoregulatory behavior. Ph.D. dissertation, University of California at Los Angeles.

Wessman, E.V. 1977. The distribution and habitat preferences of the Mohave ground squirrel in the southeastern portion of its range. Calif. Dept. Fish & Game, Wildl. Manage. Branch Admin. Rep. 77-5.

Wessman, E.V. and K.H. Berry. In press. Observations on the distribution and habitat preferences of the Mohave ground squirrel.

Zembal, R., C. Gall, D. Kruska, and P. Lobnitz. 1978. An inventory of the vascular plants and small mammals of the Coso Hot Springs Area of Inyo County, California. Submitted to Naval Weapons Center, China Lake, California.

C. CARNIVORES

Bekoff, M. 1977. Coyote biology: evolution, behavior, ecology, and management. Academic Press, New York.

California Department of Fish & Game. 1978. At the crossroads 1978 -- A report on California's endangered and rare fish and wildlife. California Department of Fish & Game, Sacramento, California.

Camenzind, F.J. 1974. Territorial and social behavior of coyotes (Canis latrans) on the National Elk Refuge, northwestern Wyoming. Jour. Colorado Wyoming Acad. Sci., 7:56.

Chesness, R.A. and T.P. Bremicker. 1974. Home range, territoriality, and sociability of coyotes in northcentral Minnesota. Paper presented at Coyote Research Workshop, Denver, Colorado.

Egoscue, H.J. 1962. Ecology and life history of the kit fox in Tooele County, Utah. Ecology, 43:481-497.

Egoscue, H.J. 1975. Population dynamics of the kit fox in western Utah. Bull. Southern California Acad. Sci., 74:122-127.

Gipson, P.S. 1974. Food habits of coyotes in Arkansas. Jour. Wildlife Mgt., 38:848-853.

Gipson, P.S. and J.A. Sealander. 1972. Home range and activity of the coyote (Canis latrans frustror) in Arkansas. Proc. Ann. Conf. Southeastern Assoc. Game and Fish Comm., 26:82-95.

Grinnell, J., J.S. Dixon, and J.M. Linsdale. 1937. Fur-bearing mammals of California. University of California Press, Berkeley, California.

Hall, E.R. and K.R. Kelson. 1959. Mammals of North America. Ronald Press, New York.

Hawthorne, V.M. 1972. Coyote food habits in Sagehen Creek Basin, northeastern California. California Fish and Game, 58:4-12.

Johnson, D.H., M.D. Bryant, and A.H. Miller. 1948. Vertebrate animals of the Providence Mountains area of California. Univ. California Publ. Zool., 48:221-375.

Knowlton, F.F. 1972. Preliminary interpretations of coyote population mechanics with some management implications. Jour. Wildlife Mgt., 36: 369-382.

Laughrin, L. 1970. San Joaquin kit fox, its distribution and abundance. California Department of Fish and Game, Wildlife Mgt. Branch, Admin. Rep. 70-2, Sacramento, California.

Morrell, S.H. 1972. Life history of the San Joaquin kit fox. California Fish and Game, 58:162-174.

Morrell, S.H. 1975. San Joaquin kit fox distribution and abundance in 1975. California Department of Fish and Game, Wildlife Mgt. Branch, Admin. Rep. 75-3, Sacramento, California.

Nellis, C.H. and L.B. Keith. 1976. Population dynamics of coyotes in central Alberta, 1964-68. Jour. Wildlife Mgt., 40:389-399.

Sargeant, A.B. and D.W. Warner. 1972. Movements and denning habits of a badger. Jour. Mammal., 53:207-210.

Snead, E. and G.O. Hendrickson. 1942. Food habits of the badger in Iowa. Jour. Mammal., 23:380-391.

Trapp, G. R. 1978. Comparative behavioral ecology of the ringtail and gray fox in southwestern Utah. Carnivore, 1:3-32.

U.S. Department of Interior, Fish and Wildlife Service. 1976. Endangered and threatened wildlife and plants. Republication of the list of species. Federal Register, 41(208):47180-47198.

WESTEC Services, Inc. 1977. Survey of Chiroptera and Carnivora in Imperial, Riverside, and San Diego Counties. Final Report, Contract No. YA-512-CT6-274. Submitted to Bureau of Land Management, Riverside District, California.

Zembal, R., C. Gall, D. Kruska, and P. Lobnitz. 1978. An inventory of the vascular plants and small mammals of the Coso Hot Springs Area of Inyo County, California. Submitted to Naval Weapons Center, China Lake, California.

REPORT V

SURVEY OF LARGE MAMMALS
IN THE
COSO GEOTHERMAL STUDY AREA

Prepared by

Susan Woodward

Jerry McDonald

July 1979

TABLE OF CONTENTS

Page

Introduction V-1

Methods V-2

Results V-7

Discussion V-16

Summary and Conclusions V-28

References V-31

TABLES

1. Browse Utilization in CGSA and Immediate Vicinity V-17

MAPS

Map 1 Roads Used for Burro Censuses V-4

Map 2 Browse Utilization Transects V-6

Map 3 Burro Census: 10 January 1979 V-8

Map 4 Burro Census: 11 January 1979 V-9

Map 5 Burro Census: 22 March 1979 V-11

Map 6 Burro Census: 18 May 1979 V-12

Map 7 Relative Use by Burros in Sampled Areas of the CGSA V-14

Map 8 Relative Use by Cattle in Sampled Sections of the CGSA V-15

Map 9 Burro Census: July-August 1978 V-25

INTRODUCTION

Large mammals require space measured in square kilometers in which to carry out their life activities. Site-specific studies are relevant only as they fit into the general pattern of habitat use by these animals. Interference with movements between seasonal ranges, decreased accessibility to free water, removal of essential cover, elimination or serious reduction of preferred forage species, or disruption of special use areas would constitute negative impacts on mammalian megafauna.

Large mammals utilizing the general region include mule deer (Odocoileus hemonius), bighorn sheep (Ovis canadensis nelsoni), feral burros (Equus asinus) and horses (E. cabalus), domestic cattle and mountain lion (Felix concolor). The probably small population of mountain lions is discussed by Zembal et al. (1978); see also Technical Report on Small Mammals and Carnivores in this volume. The mule deer, bighorn sheep and feral horse populations inhabiting the NWC generally remain well to the east and northeast of the CGSA (Barling, personal communication). NWC feral horse populations as well as burros have been recently studied by Navy personnel (ibid.). Cattle use mainly the northern portions of the area, and only during winter and spring.

The primary intent of this survey,therefore,was to study feral burros, and originally to limit that study to the non-NWC portion of the CGSA where no studies had previously been made. However, burro use of the BLM lands was infrequent, and it was necessary to follow the herd into the NWC for observation. The objective of the study has been to determine the pattern of use of the entire CGSA by feral burros. This has involved (1) an estimation of the numbers of burros using the areas, (2) determination of seasonal habitat preferences, and (3) the identification of high use areas and/or areas necessary to the maintenance of a viable burro population -- areas in which care should be taken to minimize or eliminate impacts from geothermal development to the herd and to the range, or to provide alternate sources of a plant species or habitat important to the herd. In addition, impasses to burro movements such as fences or usurpation of water sources may invite damage to facilities which could be avoided with some knowledge of the animals' movements and requirements.

The emigration of burros -- if they should be displaced from the CGSA by site development -- to adjacent areas has also been a consideration. The Haiwee Spring area, where a permanent source of water supplies numerous wildlife species such as bats, foxes, quail and songbirds and introduced species such as chukar and occasional wild horses throughout the hot summer months, was seen as one such locality where increased use by burros seemed likely if water draw-down should occur at Coso Hot Springs during geothermal development (see Hydrology sections of the ES). Therefore, this area, although not part of the CGSA, was also examined and included in censuses.

In summary, it is important to know how many burros use the CGSA, where high use areas are, and where any optimal burro habitats may be.

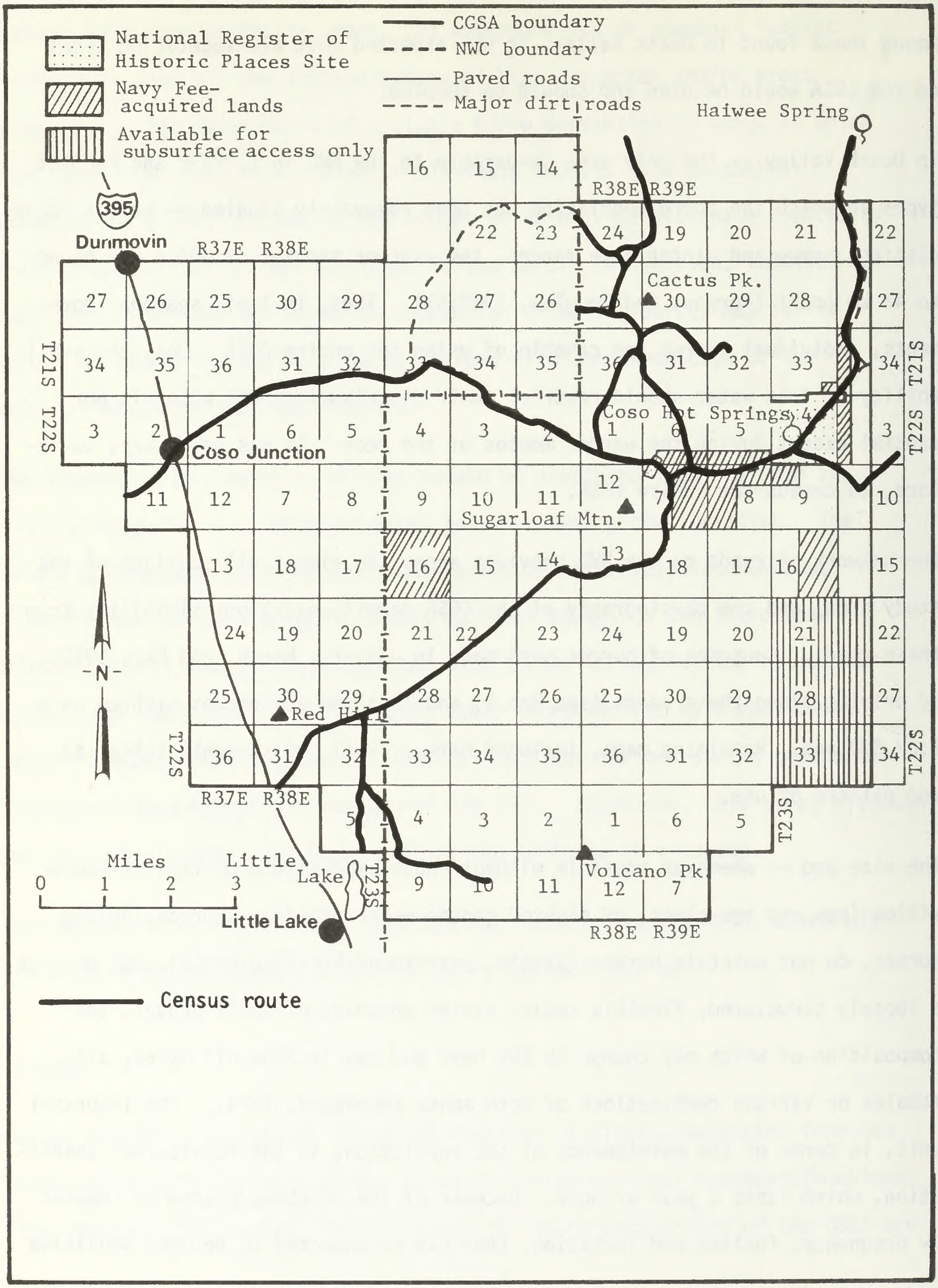
METHODS

Burros are known to utilize the whole spectrum of plant communities from low desert to bristlecone pine forest in Death Valley National Monument (Moehlman, 1974; Norment and Douglas, 1977). Since the plant communities of the CGSA are among those found in Death Valley, it was expected that all vegetation types on the CGSA would be used and should be sampled.

In Death Valley -- the only area comparable to the NWC in terrain and habitat types in which the burro population has been adequately studied -- burros occupy distinct summer and winter home ranges, the extreme margins of which may be up to 43 km apart (Norment and Douglas, 1977:51). Thus, in their seasonal movements, individual burros are capable of using the entire CGSA. Only the availability of free water should restrict their distribution, but water is not crucial except during the warmer months of the year. It was necessary, therefore, to census the entire CGSA.

The network of roads on the NWC provides access to almost all sections of the study area, and the physiography of the CGSA permits excellent visibility from these roads. Censuses of burros were made in January, March, and May, 1979, by driving along these roads (see Map 1) and locating all groups sighted on a 1:62,500 map. Resulting maps, included here, reveal the seasonal intensity and pattern of use.

The size and -- whenever possible without undue expenditure of time -- composition (sex and age-class) of sighted groups were recorded. Burros, unlike horses, do not maintain harems (stable, year-round breeding units), but possess a loosely structured, flexible social system composed of small groups, the composition of which may change by the hour and may include all males, all females or various combinations of both sexes (Woodward, 1979). The important unit, in terms of the maintenance of the population, is the female-foal association, which lasts a year or more. Because of the stresses placed on females by pregnancy, foaling and lactation, they can be expected to be more sensitive



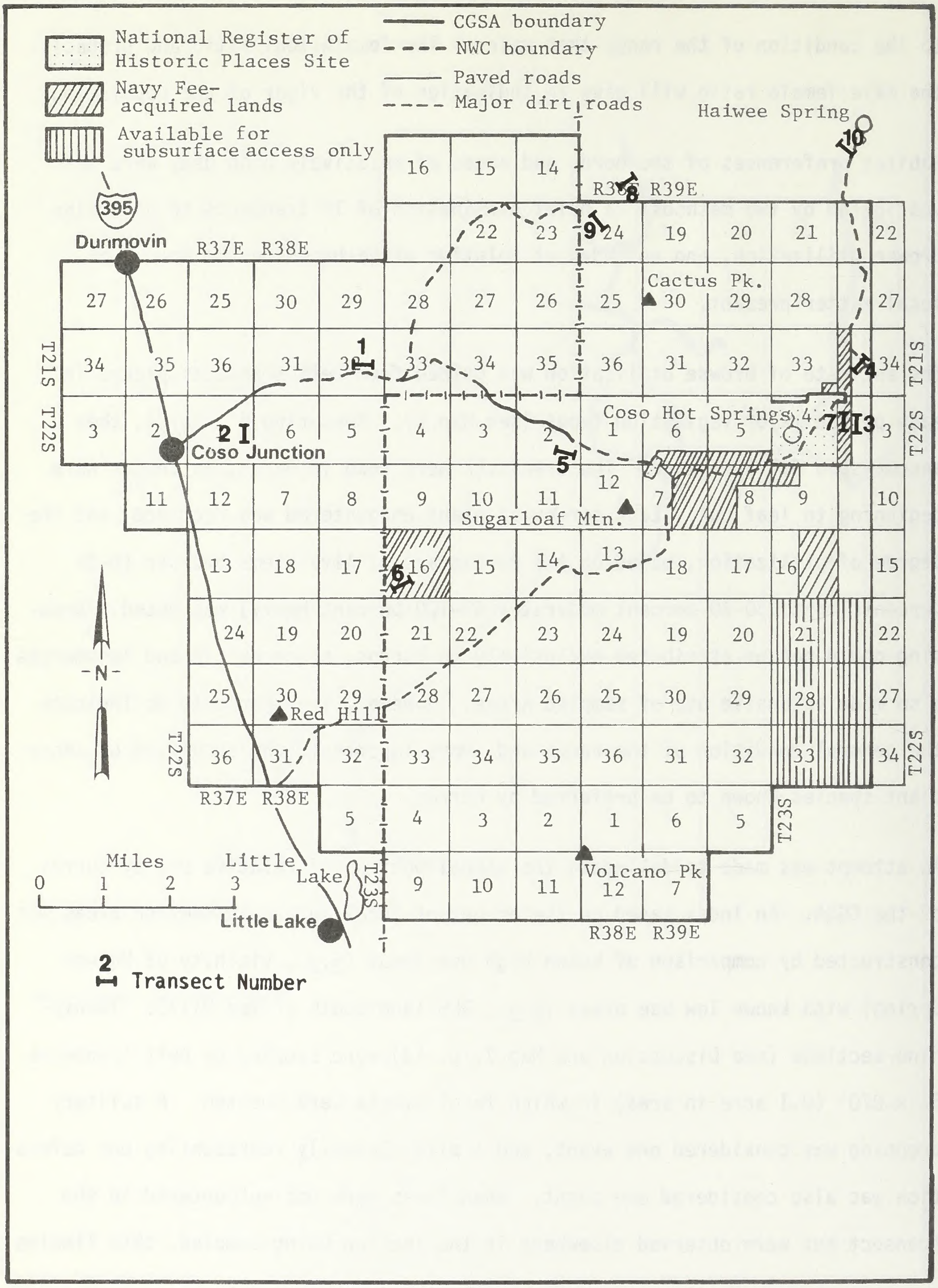
Map 1. Roads Used for Burro Censuses

to the condition of the range than males. The female:foal ratio and probably the male:female ratio will give an indication of the vigor of the population.

Habitat preferences of the herd, and areas of relatively high use, were investigated by two methods: a brief examination of 10 transects to determine browse utilization, and an index of relative usage based on the amount of fecal matter present.

The estimate of browse utilization was gained from belt transects placed in each of the major vegetation types (see Map 2). Measuring 5' x 870', they encompassed 0.1 acre each. The transects were read in March, as shrubs were beginning to leaf out. Each perennial plant encountered was recorded, and the degree of utilization, based on the percentage of live stems browsed (0-30 percent light; 30-60 percent moderate, 60-100 percent heavy) was noted. Browsing could not be attributed exclusively to burros, since cattle and lagomorphs also made extensive use of sampled areas. However, the transects do indicate the general condition of the range and, more important, the condition of those plant species known to be preferred by burros.

An attempt was made to delineate the annual pattern of relative use by burros of the CGSA. An index based on the amount of fecal matter in sampled areas was constructed by comparison of known high use areas (e.g., vicinity of Haiwee Spring) with known low use areas (e.g., BLM land south of Red Hill). Twenty-nine sections (see Discussion and Map 7, p. 14) were sampled by belt transects 5' x 870' (0.1 acre in area) in which fecal events were counted. A solitary dropping was considered one event, and a pile obviously representing one defecation was also considered one event. When feces were not encountered in the transect but were observed elsewhere in the section being sampled, this finding



Map 2. Browse Utilization Transects

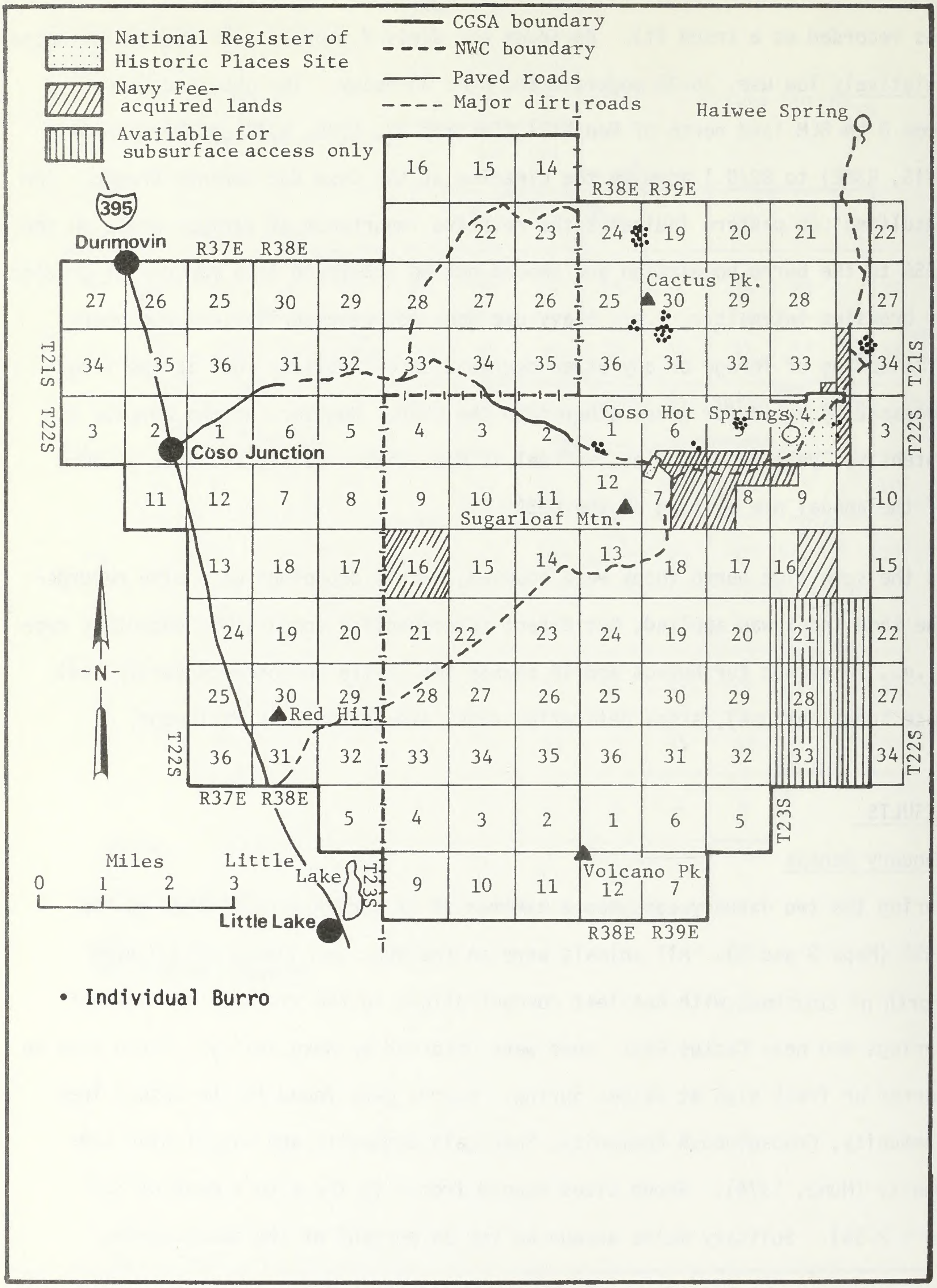
was recorded as a trace (t). An index was derived whereby t-15 events indicated relatively low use, 16-30 moderate and over 30 heavy. The observed range was from 0 on BLM land north of Red Hill (Section 12, T22S, R37E and Section 32, T21S, R38E) to 82/0.1 acre in the clearing at the Coso Hot Springs trough. The resulting use pattern indicates the relative importance of various areas on the CGSA to the burro population and should not be construed as a measure of grazing or browsing intensity: i.e., heavy use does not necessarily indicate over-utilization of forage or any other degradation of habitat. Nor is the index necessarily valid for areas other than the CGSA. However, in the absence of intensive, year long studies, we feel it does give a fairly reliable picture of the annual use pattern of the CGSA.

At the same time burro feces were counted, cattle droppings were also recorded. The same index was applied, but direct interspecific comparisons cannot be made (i.e., 10 events for burros and 10 events for cattle do not necessarily indicate identical use), since defecation rates are undoubtedly different.

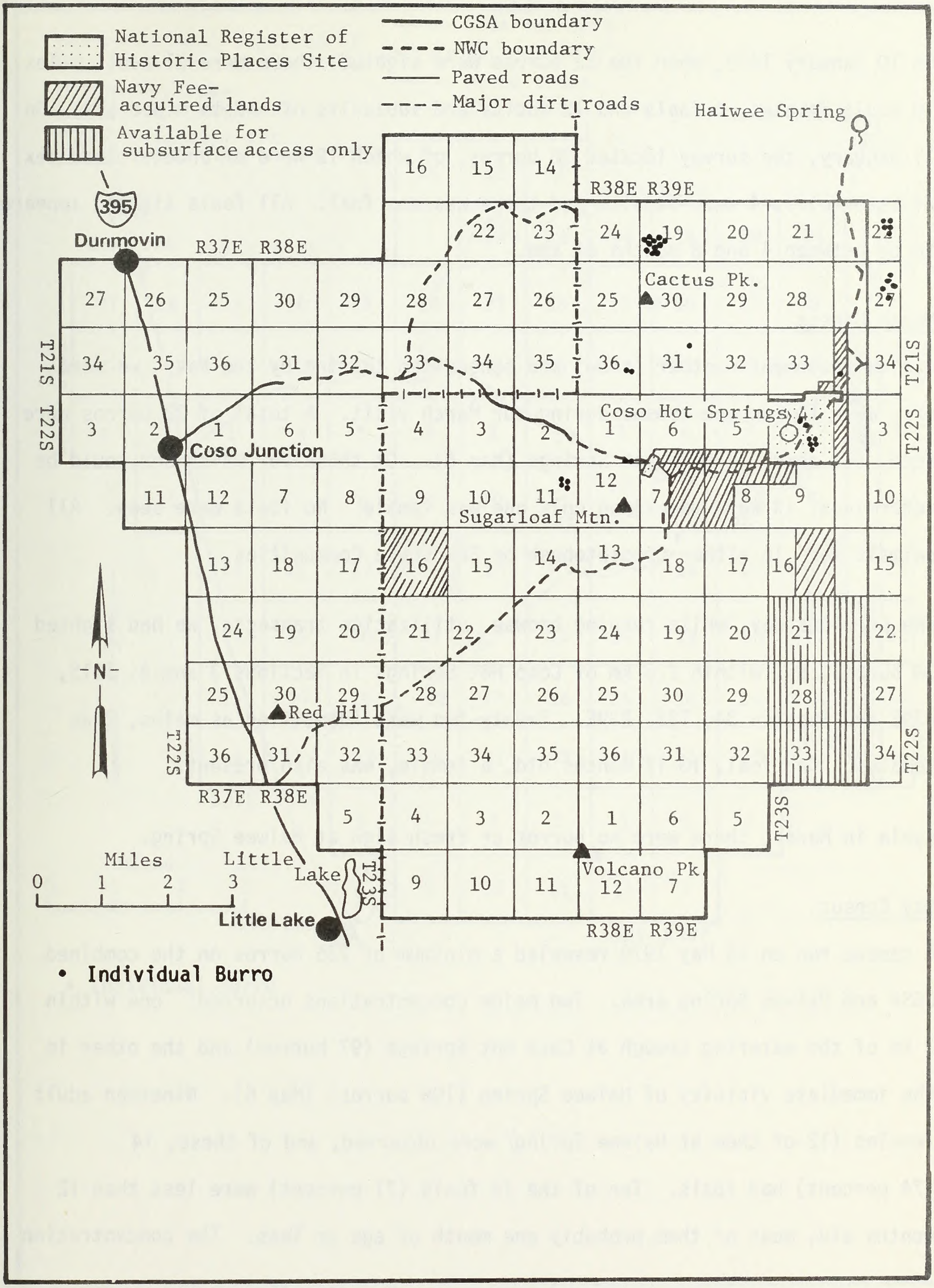
RESULTS

January Census

During the two January censuses a maximum of 52 burros were sighted on the CGSA (Maps 3 and 4). All animals were on the NWC, and virtually all were north of Coso Road,with heaviest concentrations in the vicinity of Coso Hot Springs and near Cactus Peak none were observed in Rose Valley. There were no burros or fresh sign at Haiwee Spring. Burros were found in the Joshua Tree Community, Creosotebush Community, Shadscale Community and Alkali Sink Community (Munz, 1974). Group sizes ranged from 1 to 12, with a mean of 3.6 ($\sigma = 2.96$). Solitary males accounted for 34 percent of the observations.



Map 3. Burro Census: 10 January 1979



Map 4. Burro Census: 11 January 1979

On 10 January 1979, when the 52 burros were sighted, there were 21 adult males, 10 adult females, 4 foals and 12 adults and subadults of undetermined sex. On 11 January, the survey located 38 burros, of which 12 were of undetermined sex, 21 were males, 4 were females and there was one foal. All foals sighted appeared to be between 4 and 8 months of age.

March Census

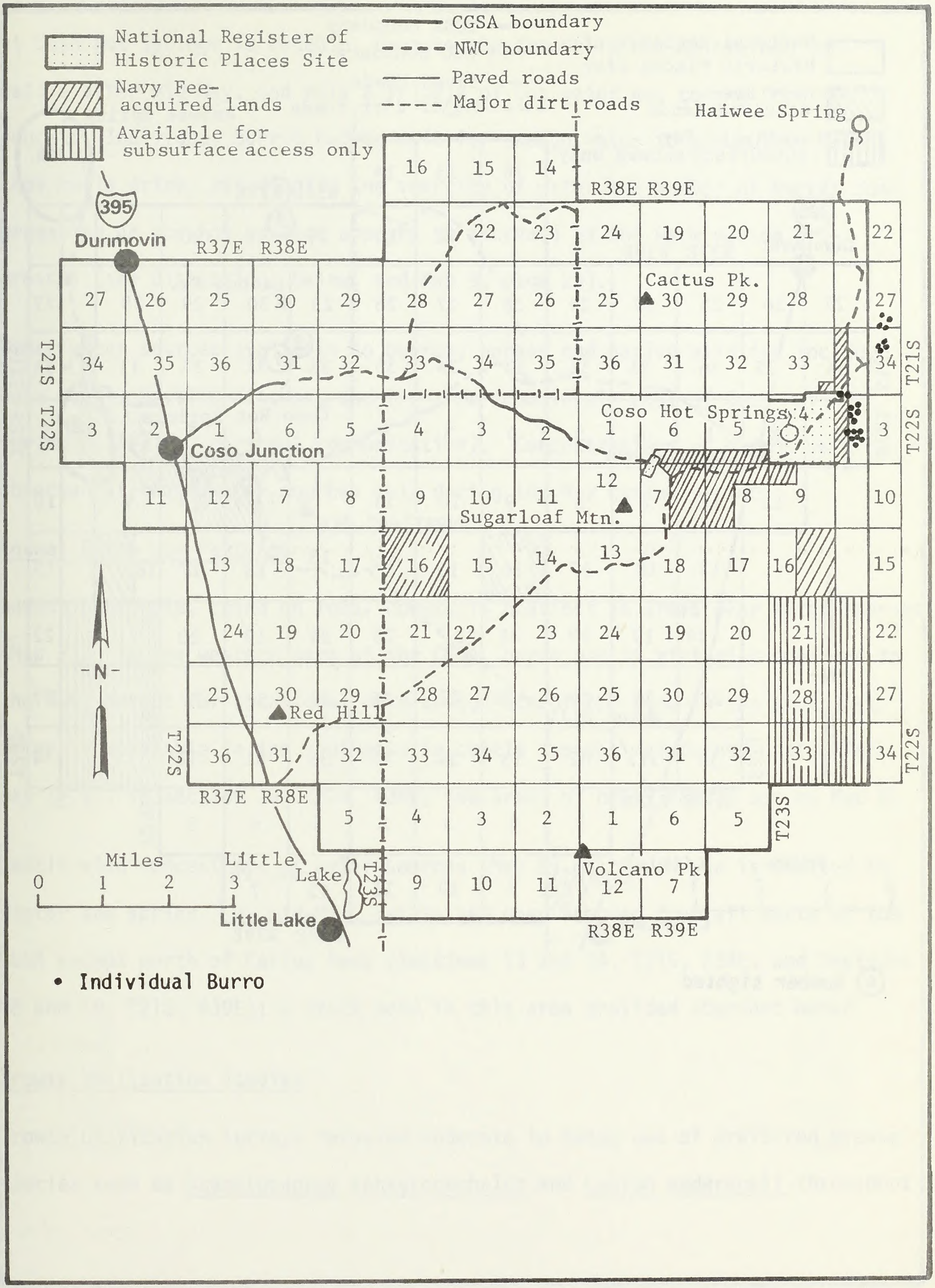
Due to inclement weather (snow) and scheduled testing by the Navy, we were only able to run one census during our March visit. A total of 22 burros were seen, all near the Coso Hot Springs (Map 5). Of those for which sex could be determined, 13 were males and only one was female. No foals were seen. All animals were in either Creosotebush or Shadscale Communities.

The previous day, while running browse utilization transects, we had sighted 38 burros, all within 2.5 km of Coso Hot Springs in Sections 3 and 4, T21S, R39E and Section 34, T22, R39E. Twenty-two were identified as males, 2 as females. One foal, 10-12 months old, a female, was also present.

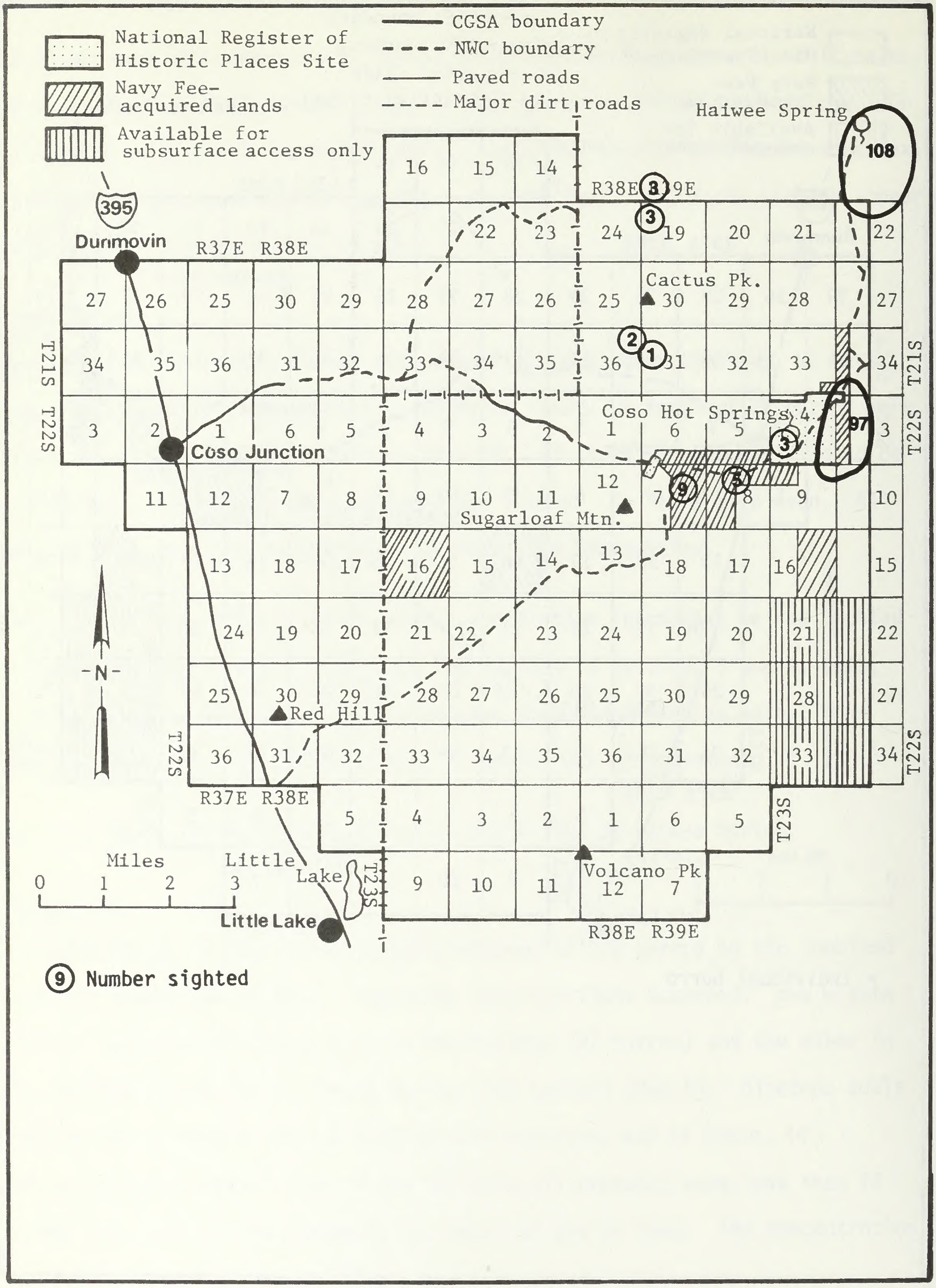
Again in March, there were no burros or fresh sign at Haiwee Spring.

May Census

A census run on 18 May 1979 revealed a minimum of 235 burros on the combined CGSA and Haiwee Spring area. Two major concentrations occurred: one within 3 km of the watering trough at Coso Hot Springs (97 burros) and the other in the immediate vicinity of Haiwee Spring (108 burros) (Map 6). Nineteen adult females (12 of them at Haiwee Spring) were observed, and of these, 14 (74 percent) had foals. Ten of the 14 foals (71 percent) were less than 12 months old, most of them probably one month of age or less. The concentration



Map 5. Burro Census: 22 March 1979



Map 6. Burro Census: 18 May 1979

at Coso Hot Springs is notable, because the trough is not maintained for cattle after mid-May, and only a trickle of hot water was coming from the faucet. Individual burros had to wait for enough water to accumulate before they could drink, yet despite the scarcity of water the number of burros congregating at the hot springs appears to increase as the warm season progresses (see Discussion, below, and Map 9, page 25).

Other water sources available to burros, horses and native wildlife include Coso No. 1, Devil's Kitchen, and the area immediately east of Coso Hot Springs (Barling, personal communication). Concentrations of burros were observed at these water sources only during the May census period.

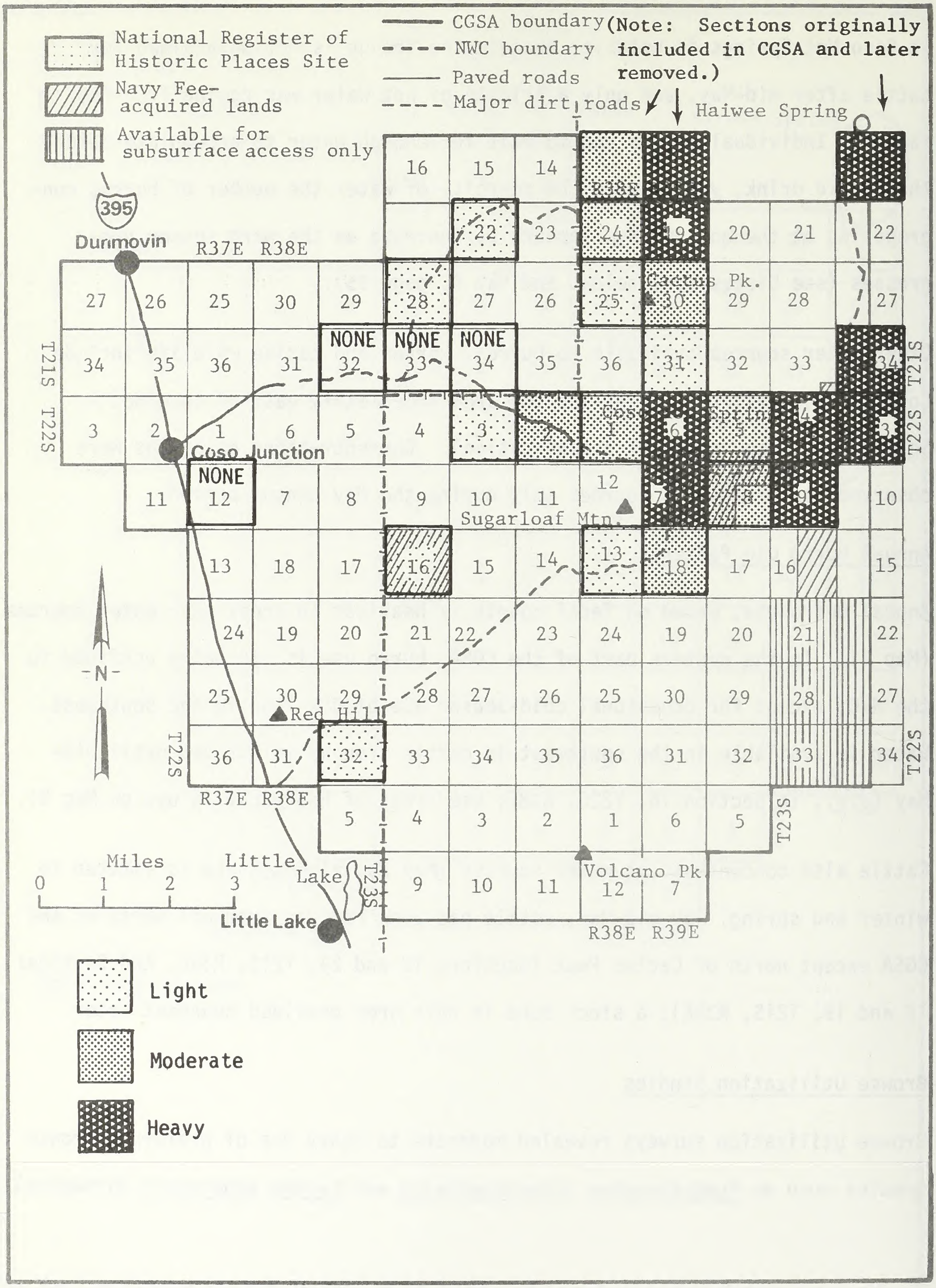
Annual Burro Use Patterns

Annual burro use, based on fecal counts,is heaviest in areas near water sources (Map 7). In the western part of the CGSA, burro use is virtually confined to the NWC, except for occasional cold-season use of BLM land in the southwest. Water is available in the southwest in cattle troughs maintained until mid-May (e.g., in Section 16, T22S, R38E; see areas of heavy cattle use on Map 8).

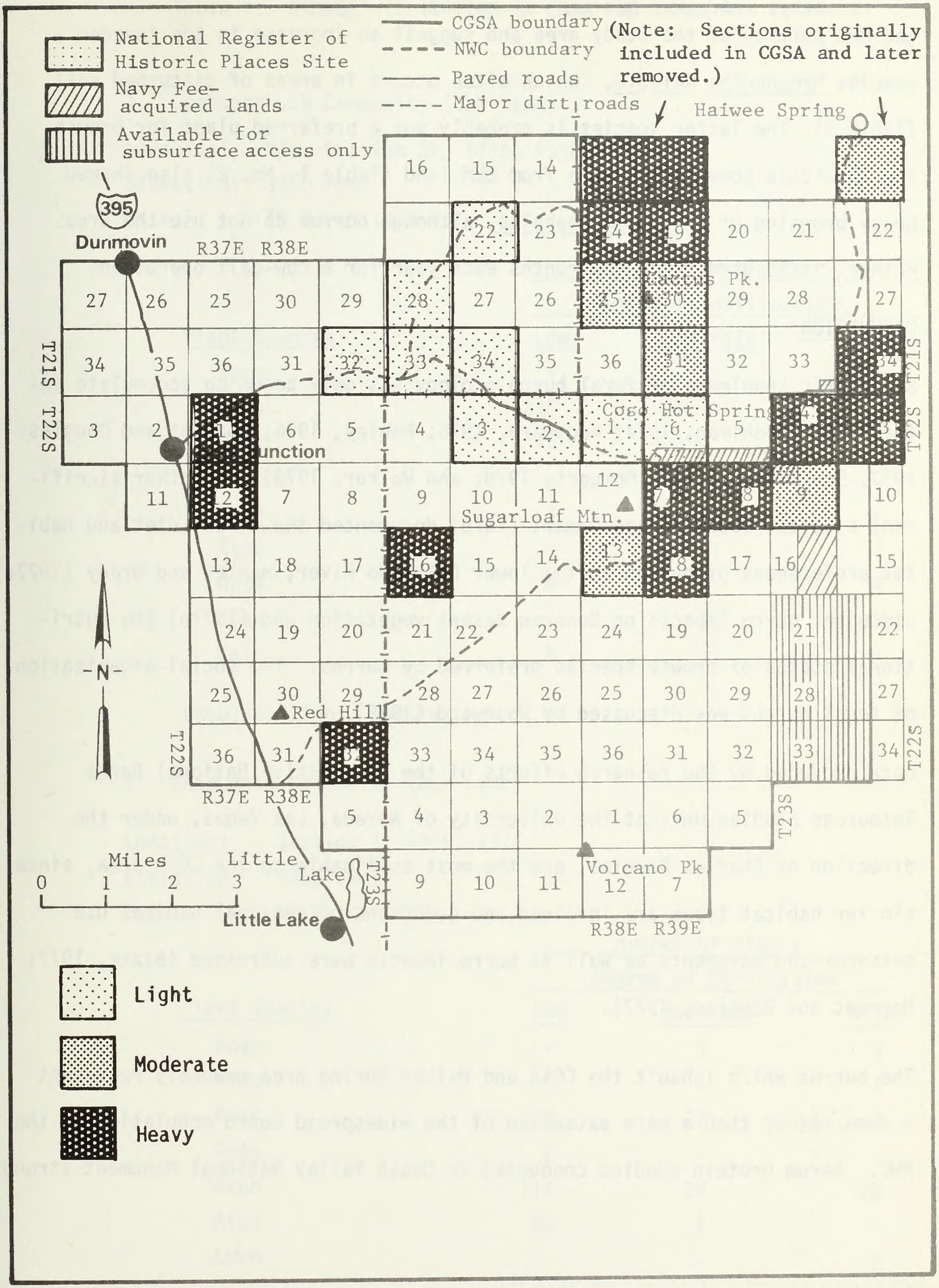
Cattle also concentrate at water sources (Map 8), although use is limited to winter and spring. By mid-May, cattle had been removed from all parts of the CGSA except north of Cactus Peak (Sections 13 and 24, T21S, R38E, and Sections 18 and 19, T21S, R39E); a stock pond in this area provided abundant water.

Browse Utilization Studies

Browse utilization surveys revealed moderate to heavy use of preferred browse species such as *Acamptopappus sphaerocephalus* and *Lycium andersonii* throughout



Map 7. Relative Use by Burros in Sampled Areas of the CGSA



Map 8. Relative Use by Cattle in Sampled Sections of the CGSA

the NWC portion of the study area and suggest an increase in the invader species Hymenoclea salsola, which often occurs in areas of disturbed soil (Table 1). The latter species is probably not a preferred plant for browse. The Shadscale Community sample from BLM land (Table 1, No. 2) also showed heavy browsing of A. sphaerocephalus, although burros do not use the area. Rather, it is used for a few months each year for a cow-calf operation.

DISCUSSION

Scientific knowledge of feral burro ecology has only begun to accumulate in the 1970s (Moehlman, 1974; Woodward, 1976; Hanley, 1976; Norment and Douglas, 1977; Seegmiller, 1977; Morgart, 1978; and Walker, 1978). In other significant studies, Woodward and Ohmart (1976) documented the annual diet and habitat preferences of burros on the lower Colorado River; Hanley and Brady (1977a) discussed burro impacts on Sonoran Desert vegetation and (1977b) the nutritional status of browse species preferred by burros. The social organization of feral burros was discussed by Woodward (1979).

Data produced by the research efforts of the Cooperative National Parks Resources Studies Unit at the University of Nevada, Las Vegas, under the direction of Charles Douglas, are the most applicable to the CGSA area, since similar habitat types are involved and questions of seasonal habitat use patterns and movements as well as burro impacts were addressed (Blake, 1977; Norment and Douglas, 1977).

The burros which inhabit the CGSA and Haiwee Spring area probably represent a deme rather than a mere extension of the widespread burro population of the NWC. Serum protein studies conducted in Death Valley National Monument strongly

Table 1. BROWSE UTILIZATION IN CGSA AND IMMEDIATE VICINITY

1. Creosotebush Community (BLM Land)

Location: SE¼, Section 32, T21S, R38E
Elevation: 3750 feet
Date: 18 March 1979

	Number of Plants		
	Degree of Utilization		
Plant Species	Low	Moderate	High
Epne	1	1	-
Amdu	218	1	4
Hysa	15	-	-
Test	-	1	-
Opba	1	-	-
Atco	-	-	1
Grsp	4	3	4
Lyan	-	2	2
Latr	8	1	-

Ungulate sign: Cattle

2. Shadscale Community (BLM Land)

Location: Section 1, T22S, R37E
Elevation: 3350 feet
Date: 18 March 1979

	Number of Plants		
	Degree of Utilization		
Plant Species	Low	Moderate	High
Acsp	-	3	5
Amdu	5	-	1
Arsp	290	17	7
Opba	2	-	-
Atco	114	22	22
Atpo	80	1	-
Lyan	-	-	2

Ungulate sign: Cattle

Table 1 (cont'd.)

3. Hymenoclea-Atriplex canescens association, Coso Hot Springs

Location: Section 3, T22S, R39E
Elevation: 3600 feet
Date: 21 March 1979

Plant Species	Number of Plants Degree of Utilization Low	 Moderate	 High
Epne	1	7	13
Hysa	73	7	5
Opba	1	7	5
Atca	5	10	17
At ?	-	1	2
Dafr	5	3	5
Lyan	-	2	2

Ungulate sign: Burro, Cattle

4. Atriplex polycarpa association, Coso Hot Springs

Location: Section 34,T22S, R39E
Elevation: 3600 feet
Date: 21 March 1979

Plant Species	Number of Plants Degree of Utilization Low	 Moderate	 High
Epne	11	6	3
Acsp	8	13	21
Hysa	47	3	2
Atca	1	-	1
Atpo	52	9	3
Dafr	3	1	1
Same	-	1	1
Lyan	-	3	4

Ungulate sign: Burro, Cattle

Table 1. (cont'd.)

5. Shadscale Community, NWC land

Location: Section 2, T22S, R38E
Elevation: 4130 feet
Date: 21 March 1979

Plant Species	Number of Plants Degree of Utilization Low	 Moderate	 High
Acsp	1	3	2
Atco	179	3	2
Dafr	1	-	-
Lyan	-	1	-

Ungulate sign: Burro, Cattle

6. Shadscale Community, NWC land

Location: Section 16, T22S, R38E
Elevation: 3400 feet
Date: 22 March 1979

Plant Species	Number of Plants Degree of Utilization Low	 Moderate	 High
Atco	39	10	4
Atpo	59	1	-

Ungulate sign: Cattle

Table 1 (cont'd.)

3. Hymenoclea-Atriplex canescens association, Coso Hot Springs

Location: Section 3, T22S, R39E
Elevation: 3600 feet
Date: 21 March 1979

	Number of Plants		
	Degree of Utilization		
Plant Species	Low	Moderate	High
Epne	1	7	13
Hysa	73	7	5
Opba	1	7	5
Atca	5	10	17
At ?	-	1	2
Dafr	5	3	5
Lyan	-	2	2

Ungulate sign: Burro, Cattle

4. Atriplex polycarpa association, Coso Hot Springs

Location: Section 34,T22S, R39E
Elevation: 3600 feet
Date: 21 March 1979

	Number of Plants		
	Degree of Utilization		
Plant Species	Low	Moderate	High
Epne	11	6	3
Acsp	8	13	21
Hysa	47	3	2
Atca	1	-	1
Atpo	52	9	3
Dafr	3	1	1
Same	-	1	1
Lyan	-	3	4

Ungulate sign: Burro, Cattle

Table 1. (cont'd.)

5. Shadscale Community, NWC land

Location: Section 2, T22S, R38E
Elevation: 4130 feet
Date: 21 March 1979

Plant Species	Number of Plants Degree of Utilization Low	 Moderate	 High
Acsp	1	3	2
Atco	179	3	2
Dafr	1	-	-
Lyan	-	1	-

Ungulate sign: Burro, Cattle

6. Shadscale Community, NWC land

Location: Section 16, T22S, R38E
Elevation: 3400 feet
Date: 22 March 1979

Plant Species	Number of Plants Degree of Utilization Low	 Moderate	 High
Atco	39	10	4
Atpo	59	1	-

Ungulate sign: Cattle

Table 1. (cont'd.)

7. Creosotebush Community, Coso Hot Springs

Location: Section 4, T22S, R39E
Elevation: 3620 feet
Date: 21 March 1979

Plant Species	Number of Plants Degree of Utilization Low	 Moderate	 High
Epne	1	1	-
Acsp	29	19	19
Amdu	2	2	2
Hysa	23	4	2
Opba	1	-	-
Dafr	1	1	1
Same	1	-	-
Lyan	1	10	20
Latr	28	2	-

Ungulate sign: Burro, Cattle

8. Joshua Tree Community, NWC land

Location: Section 13, T21S, R38E
Elevation: 5020 feet
Date: 22 March 1979

Plant Species	Number of Plants Degree of Utilization Low	 Moderate	 High
Epne	3	5	2
Acsp	1	1	2
Arsp	252	10	17
Haco	62	16	2
Atco	12	16	26
Cela	33	25	18
Lyan	1	-	-
Yubr	1	-	-

Ungulate sign: Burro, Cattle

Table 1. (cont'd.)

9. Joshua Tree Community, NWC land

Location: Section 24, T21S, R38E
Elevation: 5000 feet
Date: 22 March 1979

	Number of Plants		
	Degree of Utilization		
Plant Species	Low	Moderate	High
Epne	3	4	4
Acsp	4	10	28
Arsp	34	-	1
Haco	224	4	2
Hysa	19	7	2
Atco	56	33	33
Cela	8	23	22
Lyan	-	5	4
Yubr	2	2	-

Ungulate sign: Burro, Cattle

10. Haiwee Spring Area

Location: Section 15, T21S, R39E
Elevation: 4800 feet
Date: 22 March 1979

	Number of Plants		
	Degree of Utilization		
Plant Species	Low	Moderate	High
Epne	5	10	12
Acsp	1	-	-
Chte	1	-	-
Haco	380	-	-
Hysa	230	31	4
Test	4	1	-
Opba	1	-	-
Atco	5	22	27

Table 1. (cont'd.)

10. Haiwee Springs Area (cont'd.)

Plant Species	Number of Plants Degree of Utilization Low	Moderate	High
Cela	-	-	2
Same	10	4	6
Erfa	10	6	3
Lyan	12	11	13
Yubr	2	-	-

Ungulate sign: Burro, Cattle

suggest little or no gene flow among populations isolated during the summer peak breeding season in four valleys separated by less than 15 km (Blake, 1978). Genetic exchange among the demes was minimal despite overlaps in winter ranges.

An analogous situation seems to occur on the CGSA, where the population is also concentrated during those months which appear to be peak breeding and foaling seasons (April through August). Thus the CGSA burros should probably be considered as a management unit without regard to the estimated 1000+ burros (Barling, personal communication) on other parts of the NWC.

The 74 percent natality among the 19 adult females observed on 17 May 1979 was the production of breeding which occurred in the spring of 1978, since burros have a 12 month gestation period. The winter of 1977-78 had twice the normal precipitation and followed seven years of less than normal rainfall (Barling and McGill,personal communication). It is not known whether the 1979 natality is abnormally high for the CGSA because of this season of more abundant moisture and hence forage, or whether it is typical of the population's annual recruitment rate.

The low female:foal ratio (10:4) observed in January suggests a lower recruitment rate in 1978 than 1979, but may also reflect high foal mortality or differential migration of females with foals out of the CGSA in winter.

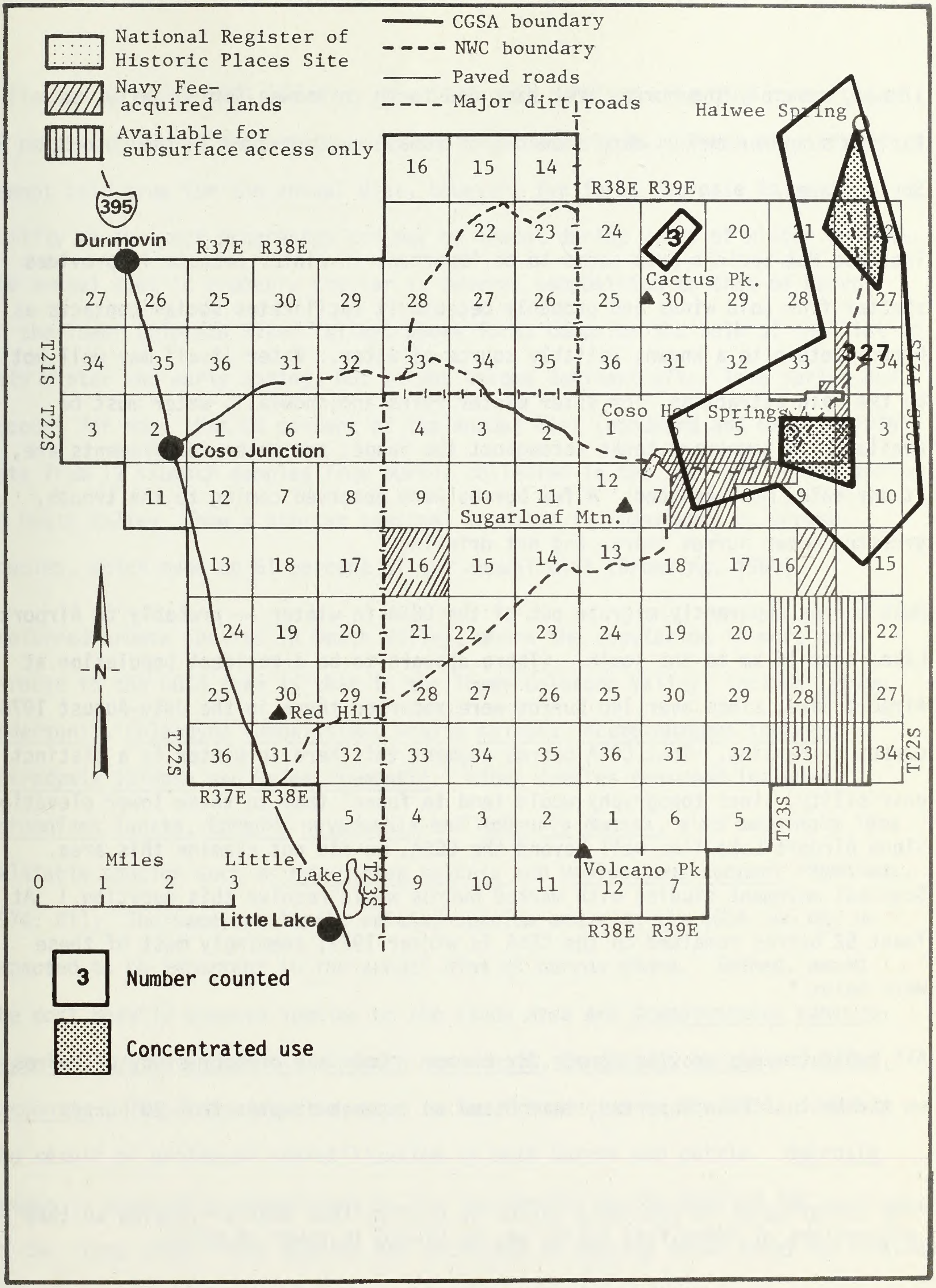
The age distribution of foals argues for a seasonal peak in breeding. The possibility exists that during the exceptionally cold winter of 1978-79, foal mortality was high, and we were observing a survivorship rather than a recruitment pattern. However, a pronounced peak in breeding is consistent with observations from other populations faced with cold winters (Moehlman, 1974; Morgart, 1978).

The area surrounding Coso Hot Springs, especially Section 3, T22S, R39E and Section 34, T21S, R39E, is of primary importance to burros occupying the CGSA in the winter months. The significance of Coso Hot Springs, including the W½ of Section 3, T22S, R39E, increases in late spring and in summer (Barling, aerial survey, July and August 1978), as burros congregate near the water source (Map 9). The valley leading from Coso Hot Springs to Haiwee Spring (Section 22, T21S, R39E and W½, Section 15, T21S, R39E) is also heavily utilized in summer months.

The Atriplex-Hymenoclea association in the W½ of Section 3, T22S, R39E, is important cover, and Atriplex canescens is consumed. The vegetation is high enough and dense enough to conceal burros and may provide vital shade for foals in summer.

Haiwee Spring, although located just off the CGSA, is significant for burros inhabiting the CGSA, because it is the only permanent water source in the immediate area. Water becomes crucial in the hot, dry summer months, not only because ephemeral natural sources of water disappear, but because the troughs maintained for cattle are also dry, the cattle having been removed from the range between April 30 and June 1. Haiwee Spring thus becomes vital to the survival of many burros, as it does for other forms of wildlife.

During our May observation period, the cattle trough at Coso Hot Springs had been turned off, but a trickle of hot water leaking from it supplied numerous burros with water. Whether this situation remains all summer is not known.



Map 9. Burro Census: July-August 1978

Source: Barling, aerial survey

If not, possibly the burros trek back and forth to Haiwee Spring daily, as Barling's summer census data show burros remain concentrated in the Coso Hot Springs area.

The Coso Hot Springs area seems to be important in winter because it provides shelter from cold winds and probably because it facilitates social contacts as burros return to a known, reliable source of water. Water itself may well not be the main attraction, for after winter rains and snowfall, water must be available in temporary tanks throughout the range, and water requirements are, at any rate, much reduced. A few burros were observed coming to the trough, greeting other burros there, and not drinking.

Most burros apparently migrate out of the CGSA in winter -- probably to Airport Lake, some 16 km to the south. (There appears to be a resident population at Airport Lake, since over 140 burros were reported there in the July-August 1978 census by Barling. That CGSA burros augment this herd in winter is a distinct possibility, since topography would tend to funnel them to these lower elevations. Since Airport Lake lies well beyond the CGSA, we did not examine this area. Seasonal movement studies with marked burros would resolve this question.) At least 52 burros remained on the CGSA in winter 1979; seemingly most of these were males.*

All habitat types provide forage for burros. Only one dietary study of burros on the NWC has been reported, that based on stomach samples from 20 burros collected in April 1966 (Zarn et al., 1977: 56). This spring diet consisted of 98 percent forbs, 1 percent grasses, and 1 percent shrubs. These proportions cannot hold true for the annual diet, however, for forbs decrease in availability as the year progresses and may be absent during years of winter drought. The annual diet is probably similar in general composition to that of burros in the lower Colorado River Valley, where forbs comprise the bulk of the diet in late winter and early spring, but shrubs become dominant after late spring and account for more than 60 percent of the annual diet (Woodward and Ohmart, 1976). Data from 19 stomach samples from burros collected in the fall and in the spring in Death Valley show a similar seasonal increase in importance of browse species, which made up 51 percent of the annual diet (Browning, 1960).

---

*The sex of males is generally easier to confirm than that of females so that proportions of identified burros may be biased in favor of males.

Preferred browse species in Death Valley, where the vegetation is more comparable to the CGSA than is that in the lower Colorado Valley, include Lycium andersonii, Coleogyne ramosissima, Grayia spinosa, Acamptopappus shockleyi, Tetradymia spinosa and Dalea fremontii. Other species consumed included Cerotoides lanata, Ephedra nevadensis and Ambrosia dumosa, also seemingly less palatable species such as Hymenoclea salsola and Haplopappus cooperi (Moehlman, 1974: 81). The same or closely related species occur on the CGSA and may be expected to be important in the annual diet of burros there. Indeed, among the most heavily browsed species on the study area are Acamptopappus sphaerocephalus, Lycium andersonii, Ephedra nevadensis, Cerotoides lanata and Dalea fremontii. These species also occur in low frequencies on the CGSA, probably the result of prolonged overutilization by both burros and cattle. Ambrosia dumosa is especially conspicuous by its low density on the sampled NWC portions of the study area. This species has decreased in density under heavy utilization by burros (and hares) along the lower Colorado River (Hanley and Brady, 1977a). In Death Valley, Ambrosia and also Acamptopappus are being adversely affected by burros (Norment and Douglas, 1977: 89). The low frequency of Ambrosia on the NWC may, at least in part, be due to pressures from burros.

The more unpalatable species (e.g., Larrea tridentata, Hymenoclea salsola, Haplopappus cooperi) remain more or less untouched, in contrast to overutilized areas in Butte Valley, Death Valley National Monument, where Creosotebush reportedly becomes important in the diet of burros (California Department of Fish and Game, 1972).

SUMMARY AND CONCLUSIONS

The CGSA receives seasonally variable use by feral burros, with observed numbers ranging from 52 in winter to over 300 in summer. In all seasons Coso Hot Springs and adjacent valleys leading to Haiwee Spring receive the heaviest use.

Although the main purpose of this technical report is to describe the burro population of the CGSA, it is important to note that the range is in generally poor condition throughout the study area due to prolonged overutilization by cattle on BLM land and by a combination of cattle and feral burros on NWC land. A reduction in use by both ungulates would serve to improve the quality of the range. Plant species most heavily impacted include Lycium andersonii and Acamptopappus sphaerocephalus. The low frequency of perennial grasses and Ambrosia dumosa may also reflect overutilization by domestic and feral stock. If geothermal development occurs in areas where burro use is heavy, browse impacts may be shifted to other areas.

Water is the most limiting resource for feral burros on the CGSA, although the nutritional quality of the forage is obviously also significant for maintenance and reproduction. The cattle trough at Coso Hot Springs,and Haiwee Spring, just outside the northeast corner of the study area, are thus areas important to the survival of the herd. Haiwee Spring, a perennial flow sheltered by willows and other dense vegetation, is more important for other wildlife than is the Coso Hot Springs area.

The impact on Haiwee Spring during summer months, should burros be denied access to Coso Hot springs, may be somewhat more predictable. The relative importance of the level expanse, forage, cover and the trickle of water at the trough at Coso Hot Springs in the summer months has not been evaluated. Studies of daily movements of marked animals during the summer would reveal the degree to which burros congregating at Coso Hot Springs utilize the Haiwee Spring area during that season under present conditions. However, in view of the distance between the two locations (approximately 8 km), and in light of present knowledge concerning the distribution of burros around point water sources during summer months (2-3 km), it seems unlikely that there presently is much summer use made of Haiwee Spring by burros which gather at the hot springs. Thus, we would anticipate increased pressures on the Haiwee environment should the trough be removed (or repaired) or water otherwise denied burros at Coso Hot Springs. The Haiwee Spring area is already overbrowsed, most of the palatable species either severely hedged or virtually absent. Increased use by burros would further degrade the habitat on the interfluves and undoubtedly severely stress the burro herd (through malnutrition and possibly mere crowding), particularly and initially the females. If additional water sources are made available to burros through mitigation measures related to geothermal development, impacts on Haiwee Spring would, of course, be reduced.

REFERENCES

Barling, T., 1977. Environmental Analysis Report, Phase 1 of Coso Geothermal Project. NWC, Public Works Department.

Barling, T., 1978. Hand-reproduced map of July-August 1978 feral horse and burro census. (Also personal communication

Blake, J. G., 1977. "Serum protein polymorphisms of the feral ass (Equus asinus) in Death Valley National Monument." Contribution CPSU/UNLV No. 23, Cooperative National Park Resources Studies Unit, University of Nevada, Las Vegas.

Browning, B., 1960. "Preliminary report of food habits of wild burro in Death Valley National Monument." Desert Bighorn Council Transactions 4: 88-90.

California Department of Fish and Game, 1972. "The status of feral burros in California." Unpublished report of the Wildlife Management Branch, The Resources Agency, State of California, 8 p.

Hanley, T. A., 1976. "Carrying capacity relationships of feral burro (Equus asinus) habitat in a Sonoran Desert Ecosystem." MS Thesis, Arizona State University, Tempe, 156 p.

Hanley, T. A., and W. W. Brady, 1977a. "Feral burro impact on a Sonoran Desert range." J. Range Manage. 30: 374-377.

Hanley, T. A., and W. W. Brady, 1977b. "Seasonal fluctuations in nutrient content of feral burro forages, lower Colorado River valley, Arizona." J. Range Manage. 30: 370-373.

McGill, Thomas J., Natural Resources Specialist, Naval Weapons Center, China Lake, California. Personal communication, 1979.

Moehlman, P. D., 1974. "Behavior and ecology of the feral ass (Equus asinus)." PhD Dissertation, University of Wisconsin, Madison, 251 p.

Morgart, J. R., 1978. "Burro behavior and population dynamics, Bandelier National Monument, New Mexico." MS Thesis, Arizona State University, Tempe, 94 p.

Munz, P.A., 1974. A Flora of Southern California. Berkeley: University of California Press, 1086 p.

Norment, C., and C. L. Douglas, 1977. "Ecological studies of feral burros in Death Valley." Contribution CPSU/UNLV No. 17, Cooperative National Park Resources Studies Unit, University of Nevada, Las Vegas, 132 p.

Seegmiller, R. F., 1977. "Ecological relationships of feral burros and desert bighorn sheep, western Arizona." MS Thesis, Arizona State University, Tempe, 135 p.

Walker, M. 1978. "Ecological similarities between feral burros and desert bighorn sheep, Black Mountains, southwestern Arizona." MS Thesis, Arizona State University, Tempe, 127 p.

Woodward, S. L., 1976. " Feral burros in the Chemehuevi Mountains, California: the biogeography of a feral exotic." PhD Dissertation, University of California, Los Angeles, 178 p.

Woodward, S. L., 1979. "The social system of feral asses." Zeitschrift fur Tierpsychologie 49: 304-316.

Woodward, S. L. and R. D. Ohmart, 1976. "Habitat use and fecal analysis of feral burros (Equus asinus), Chemehuevi Mountains, California, 1974." J. Range Manage. 29: 482-485.

Zarn, M., T. Heller and K. Collins, 1977. "Wild, free-roaming burros -- status of present knowledge." Technical Note 196, U.S. Department of the Interior and U.S. Department of Agriculture, 65 p.

Zembal, Richard, Barbara W. Massey and Thomas E. LaRocque, 1978. "Winter Season Bird Populations Studies in the Coso Geothermal Area of Inyo County, California." Report to US Department of the Interior, Bureau of Land Management, Bakersfield District. Also in American Birds, 33:1.

REPORT VI

BOTANY OF THE COSO GEOTHERMAL STUDY AREA

Technical Report by

James Henrickson

September 1979

TABLE OF CONTENTS

Page

INTRODUCTION VI-1

METHODS VI-3

Vegetation Map VI-3
Quantitative Sampling VI-5
Vascular Flora VI-9
Rare, Endangered, and Regionally Endemic Plants VI-10

RESULTS AND DISCUSSION VI-11

Literature Review of Vegetation of the Mojave Desert and the Great Basin VI-11
Mojave Desert VI-11
Creosotebush Scrub VI-12
Mixed Desert Scrub VI-14
Joshua Tree Woodland VI-15
Alkali Sink Scrub VI-17
Saltbush Scrub VI-18
Great Basin VI-19
Great Basin Sagebrush VI-19
Pinyon-Juniper Woodland VI-20
Human Impacts on Desert Environments VI-21
Summary: CGSA Associations VI-22
Annuals VI-23
Quantitative Data on Vegetation VI-24
Atriplex confertifolia VI-24
Atriplex polycarpa VI-30
Atriplex canescens VI-34
Chrysothamnus nauseosus VI-37
Ambrosia dumosa VI-37
Mixed Desert Scrub VI-41
Larrea tridentata VI-46
Yucca brevifolia VI-48
Volcanic Peaks VI-51
Disturbed, Cultivated, Open and Barren Areas VI-52
Haiwee Spring VI-56
Little Lake and Lower Ponds VI-57
Summary of Rare, Endangered and Locally Endemic Plants VI-59

VASCULAR FLORA OF THE CGSA VI-63

REFERENCES VI-92

TABLES

TABLE NO. — Page

1 Aerial Photograph Characteristics of Identification Classes VI-4

2 Standardized Abbreviations for Plants Listed in Tables 4-10 VI-7

3 Plant Communities of the Mojave Desert of California VI-8

4 Atriplex confertifolia (Shadscale) VI-27

5 Atriplex polycarpa (Allscale) VI-32

6 Atriplex canescens (Four-winged Saltbush) VI-36

7 Ambrosia dumosa (Burro Weed); Larrea tridentata (Creosote Bush) VI-40

8 Mixed Desert Scrub VI-43

9 Yucca brevifolia (Joshua Tree) VI-50

10 Volcanic Habitats VI-53

FIGURES

FIGURE NO.

1 Vegetation of the CGSA (Composite, oversize; on file in the Bakersfield Office of the Bureau of Land Management)

2 CGSA Vegetation Sample Sites VI-6

3 Distribution of Shadscale and Bud Sage VI-25

4 Distribution of Allscale VI-31

5 Distribution of Four-winged Saltbush and Rabbit Bush VI-35

6 Distribution of Burro Weed VI-39

7 Distribution of Mixed Desert Scrub VI-42

8 Distribution of Creosote Bush VI-47

9 Distribution of Joshua Tree VI-49

10 Disturbed, Cultivated, Open and Barren Areas VI-54

EXHIBITS

EXHIBIT NO.		Page
1	Plant Species Field Data Report: *Spartina gracilis*	VI-89
2	Plant Species Field Data Report: *Pholisma arenarium*	VI-90
3	Plant Species Field Data Report: *Canbya candida*	VI-91

INTRODUCTION

The 294-km^2 (113.5-mi^2) Coso Geothermal Study Area is situated in the northwestern Mojave Desert along the eastern margin of the Sierra Nevada in southwestern Inyo County. The site, which ranges from 833 to 1814 m (2730-5947 ft), is characterized by hot, dry summers and cool, moist winters. Rainfall comes mostly during the months November through March; May through September are the driest months, though summer thunderstorms may bring rain during any of these months. Average rainfall at Haiwee Reservoir just north of the site at 3600 ft averaged 171.4 mm (6.76 in) from 1965 to 1975 but precipitation is highly variable from year to year with a range of 59-309 mm (2.33-12.18 in) (U.S. Weather Bureau Data). Precipitation at the Naval Weapons Center, ca. 61 km (38 mi) to the south at 680 m (2229 ft), averaged only 74 mm (2.9 in) from 1946-73 (Zembal, et al., 1978b). No long-term records have been made on the site. Data from Beatley (1975, 1976) from the Nevada Test Site indicate that precipitation and temperature (which increase and decrease respectively with elevation) would play an important role in plant distributions on this site. These data may not be strictly applicable to the CGSA, which lies within the rain shadow cast by the Sierra Nevada, and is entirely below 6000' in elevation. However, the vegetative cover at the Nevada Test Site is generally comparable to that of the study area. The effect of altitudinal differences upon precipitation and vegetation can be more clearly discerned at higher elevations to the east of the study area, for example at Coso Peak (8160').

In addition to elevational and climatic diversity, the site has a rather broad diversity of physical (edaphic) habitats ranging from fine to coarse sandy plains and basins, alluvial fans, granitic and basaltic rocky slopes and hillsides to clay pans, playas, young to old lava fields (some overlain with windblown sands), as well as large to small cinder cones with fine sandy to coarse rocky or pumice slopes (see Geology and Soils Technical Report). In addition there are active hot springs, geothermically produced outcroppings of calcite, disturbed flats and saline to fresh water habitats around Haiwee Spring and Little Lake.

Most of the site, particularly that on the fine to coarse sandy-silty plains and lower slopes, is covered with a rather monotonous scrub vegetation, the density and specific composition of which gradually varies from place to place; sometimes it is associated with obvious soil, climatic or exposure changes, at other times it is apparently quite independent of any obvious alterations in physical habitat. At higher elevations, vegetation usually exhibits a richer diversity in species, reaching a maximum on the steep rocky slopes or flats on the tips of ridges and larger cinder cones. Overlying this scrub vegetation is a broken cover of more conspicuous species such as creosote bush (Larrea tridentata) and occasionally Joshua trees (Yucca brevifolia).

In any analysis of vegetation, it is convenient to divide the plant cover into specific vegetation associations, and in many areas this is easily done. But on this particular site, the artificiality of these designations becomes readily apparent. There are extensive areas of Shadscale Scrub dominated by shadscale (Atriplex confertifolia) and other areas of Creosote Bush Scrub consisting of Larrea tridentata with an understory of burro-weed (Ambrosia dumosa), which are easily recognizable vegetation associations that are widespread in the Mojave or Great Basin Deserts. There are also localized areas of Joshua trees which evoke the designation of Joshua Tree Woodland even though the understory may be dominated by shadscale scrub or a Larrea-Ambrosia dumosa-dominated Creosote Bush Scrub or a highly diverse assemblage of shrub species including hopsage (Grayia spinosa), cheesebush (Hymenoclea salsola) and California buckwheat (Eriogonum fasciculatum ssp. polifolium) which together constitute a distinct but highly variable vegetation type which has not been widely recognized or well analyzed in the Mojave Desert -- a Mixed Desert Scrub. There also is strong intermingling of all the above vegetation types over broad areas of transition and other outcroppings of nearly pure to mixed stands of allscale (Atriplex polycarpa) or four-winged saltbush (Atriplex canescens) in often localized areas associated with sandy flats or clay pans.

While some of this diversity in vegetative cover is due to edaphic and micro-climatic variation on the site, in other areas rather abrupt changes in species composition appear to be quite independent of these factors. Because of this, the researchers stayed away from a conventional reliance on vegetation types in the treatment of vegetative cover on the site, leaning more towards Gleason's (1926, 1939) individualistic concept of plant associations, and recognizing that vegetation cover in any one place is the result of migration and environmental selection of individual species.

This study presents an overall inventory of vegetational resources on the CGSA with emphasis on designated rare and endangered and sensitive species. A vegetation map, derived from aerial photography and checked by extensive ground reconnaissance, presents the distribution of major recognizable uni- to multi-specific vegetation associations on the site. The species composition of each vegetation association (i.e., polygon type), density (expressed as cover) and relative abundance (expressed as percent frequency) of shrubby species were established by extensive and intensive quantitative sampling. Quantitative data are presented in tabular form, and composition of each major vegetation type is discussed. Distribution of constituent species in the CGSA is noted elsewhere.

A check list of all known species of vascular plants known to occur within the CGSA, Haiwee Spring, and Little Lake areas is presented along with data on relative frequencies of each species in major vegetations.

All species indicated as rare and endangered, rare but not endangered, not rare but of limited distribution by the California Native Plant Society (Powell, 1974) and as endangered and threatened by the Federal Fish and Wildlife Service are listed with data and maps on the distribution on the site; the appropriate Plant Species Field Data Forms S11 are presented for each species noted. Regionally endemic plant species are also noted and their frequency and distribution discussed. These data are provided to give sufficient information on the flora to allow recognition of particular sensitive and significant habitats and species within the CGSA, to determine potential impacts on vegetation resources resulting from the proposed geothermal exploration and development in the CGSA, and to develop measures to mitigate potential impacts.

VEGETATION MAP

Vegetation of the CGSA was mapped from Kodak Ektachrome infrared aerial photography (Type 2443) at a scale of 1:12,000. The aerial reconnaissance was flown in December 1978. Except for some vignetting, the film was properly exposed and reproduced on 9 inch square transparencies. The vegetation was interpreted over a light table with a Bausch and Lomb zoom stereoscope with up to 15X magnification. The initial map was constructed in the laboratory exclusively by R. Minnich and modified during extensive field reconnaissance by J. Henrickson.

Color infrared film has many advantages over other film types for the study of plant life. Besides providing greater contrast through the use of false colors and superior atmospheric penetration, plants may also be identified on the basis of color record in addition to patterns produced by physiognomic characteristics.

Aerial analysis of vegetation by color record may be complicated by seasonal changes in visible and near infrared reflectances of various plant species. Such changes may be of advantage, however, if they can be related to phenology, i.e., if the plant is flowering, in fruit or deciduous. In this study the photography was flown when many subligneous subshrub species were in heavy fruit (Atriplex confertifolia, Atriplex canescens) and others were deciduous.

The vegetation classification is ultimately a floristic construct, representing associations of woody plants which are important in the biomass of the region. Taxonomic identification from aerial photographs required the appearance of a species imagery to be as familiar to the interpreter as their field appearance. This involved conventional taxonomic identification and determination of gross physical features which made them recognizable at a distance in the field and potentially from the vertical. The process is one of information transferred from the field to film and vice versa. In the field, individual specimens or plants covering entire slopes were plotted, identified on topographic quadrangles, and checked on the imagery. Conversely, in the laboratory, field-identified vegetation signatures were sought elsewhere on the imagery and checked in the field in order to develop consistent species identification throughout the study area. This process continued until there were no new mysteries to be learned from the imagery.

What proved to be diagnostic criteria varied with the species (Table 1). The largest dominant species, Yucca brevifolia and Larrea tridentata, were easily identified from their much greater size compared with prevailing subshrub vegetation. Subshrubs were identified largely from color record which for the most part reflected fruiting behavior and the deciduous habit.

Unfortunately, not all species were individually recognizable from aerial photography due to their physical similarity, especially the subshrubs. This is to be expected, as many species cannot be distinguished in the field except by careful examination of detailed features such as flower parts. It was decided to group species with common physiognomy and color record on photography into identification classes of species sets. These species cannot be definitively separated from one another but can be recognized as different from other species sets and single species.

Table 1. Aerial Photograph Characteristics of Identification Classes

	IDENTIFICATION CLASS	PHYSIOGNOMY	HEIGHT	COLOR	CROWN APICES	CROWN MARGINS	PERIMETER SHAPE	DISTANCE CROWN TO GROUND
Trees	*Yucca brevifolia*	small tree	2-6 m	pink	narrowly rounded	parted	sparse columnar	1-4 m
	Populus fremontii	medium tree	5-15 m	deciduous	narrowly rounded	sinuate	limbs show	1-5 m
Woody Shrubs	*Larrea tridentata*	medium shrub	1-3 m	red	inverted	deeply serrate	fine texture, frayed	contiguous
	Salix spp	large shrub	2-4 m	deciduous	broadly rounded	entire	limbs show	contiguous
Subshrubs	*Ambrosia dumosa* + other species	small subshrub	2-5 dm	white	broadly rounded	--	rounded	contiguous
	Atriplex confertifolia + other species	small subshrub	3-10 dm	dark gray	broadly rounded	--	rounded	contiguous
	Atriplex polycarpa	medium subshrub	5-15 dm	white	broadly rounded	entire	rounded	contiguous
	Atriplex canescens	small subshrub	2-5 dm	yellow	broadly rounded	--	rounded	contiguous
	Mixed subshrubs	small subshrubs	3-10 dm	dark gray	broadly rounded	--	rounded	contiguous
	Lycium spp	medium subshrub	1-3 m	red	broadly rounded	sinuate to entire	rounded	contiguous
	Cinder cone vegetation	small to medium subshrubs	3-15 dm	mostly yellow	variable	--	rounded	contiguous
	Artemesia spinescens	small subshrub	2-5 dm	black	broadly rounded to flat	--	rounded	contiguous
	Chrysothamnus nauseosus	medium subshrub	5-15 dm	yellow	broadly rounded	entire	rounded	contiguous
Herbaceous Vegetation		Herbaceous and annual	< 5 dm	yellow	unresolved	unresolved	unresolved	contiguous

A total of nine identification classes are shown on the vegetation map. These are arranged into four physiognomic classes: trees, woody shrubs, subshrubs and herbaceous vegetation (Table 1). Each class had to exceed ca. five percent cover to be mappable, with the exception of the Joshua tree (Yucca brevifolia) which was mapped at one percent cover.

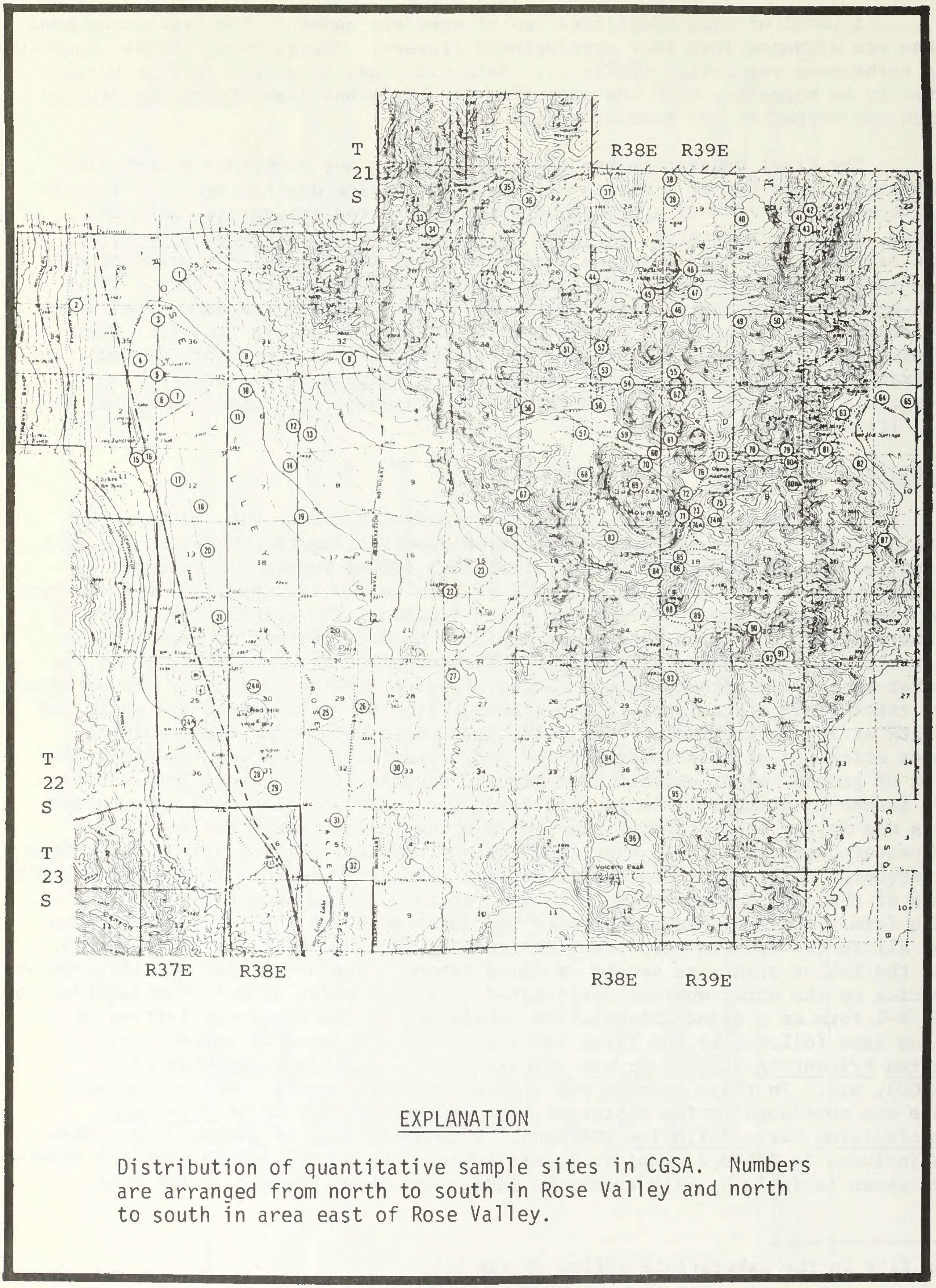
The final vegetation map (Fig. 1)[1] consists not of mutually exclusive vegetation types but of a series of often overlapping distributions of individual component species (i.e., Yucca brevifolia, Larrea tridentata, Ambrosia dumosa, Atriplex polycarpa, Atriplex canescens, Chrysothamnus nauseosus) and more complex vegetation types as Shadscale scrub (with local dominance of bud sage (Artemisia spinescens) indicated separately), Mixed Desert Scrub, areas with herbaceous vegetation and cultivated areas. In most instances the vegetation components (types) are indicated on the map by colors (tones). Overlapping of these areas is indicated by stripping of the two colors (tones). Distribution of Yucca brevifolia and Larrea tridentata is indicated by an overgrid of lines or dots. Each vegetation component is mapped separately as well (Figs. 3-9).

QUANTITATIVE SAMPLING

Quantitative data were obtained from 99 sites (see Fig. 2) over the CGSA distributed over all major vegetation associations recognized on the site, using the California Desert Conservation Area (CDCA) vegetation transect procedures with data taken on CDCA Form V-1. The method employed followed written and verbal instructions provided by Hyrum Johnson. The quantitative sampling teams consisted of James Henrickson assisted by Peggy Watson or Esther Lee and Barry Prigge assisted by Bill Weaver. The technique is a modification of the Parker three-step method where a series of point intercepts (dot counts or hits) are taken along a straight-sighted transect line of undetermined and unlimited length at 3-pace intervals. The point intercepts were made with a pointed meter stick and at each intercept the following information was recorded: the type of ground cover, whether bare ground, organic litter, small rock (under two inches in diameter), large rock (over two inches in diameter) and whether this was in the open or under cover of a plant, except where the intercept represented a basal hit of a perennial plant species. If the point intercepted a perennial plant (data on annuals was not taken) the maximum height of the main mass of this species measured in cm was recorded in the proper place on the V-1 data form. If more than one species was intercepted at a point, data on both (or all three) species were taken designating the lowest as the first canopy, and the taller plants as second or third canopy. The occurrence of all perennial species on the site, whether intercepted by a data point or not, was recorded on the V-1 form as a coded abbreviation consisting of the first two letters of the genus name followed by the first two letters of the specific epithet, e.g. Larrea tridentata (LATR), Grayia spinosa (GRSP), Atriplex confertifolia (ATCO), etc. In those species represented by infraspecific taxa on the site this was continued to the subspecies or varietal epithet as in Eriogonum fasciculatum var. polifolium (ERFApo). A complete list of abbreviations used is included in Table 2. Mojave Desert communities recognized by Munz and others are shown in Table 3, with asterisks indicating those present on the CGSA.

---

[1] On file in the Bakersfield office of the BLM.



EXPLANATION

Distribution of quantitative sample sites in CGSA. Numbers are arranged from north to south in Rose Valley and north to south in area east of Rose Valley.

Figure 2. CGSA VEGETATION SAMPLE SITES

Table 2 Standardized abbreviations for plants listed in Tables 4-10.

ACSP	*Acamptopappus sphaerocephalus*
AMDU	*Ambrosia dumosa*
ARSP	*Artemisia spinescens*
ARTR	*Artemisia tridentata* ssp. *tridentata*
ASLE	*Astragalus lentiginosus* var. *variabilis*
ATCA	*Atriplex canescens*
ATCO	*Atriplex confertifolia*
ATPO	*Atriplex polycarpa*
CHNA	*Chrysothamnus nauseosus*
CHTE	*Chrysothamnus teretifolius*
DAFR	*Dalea fremontii* var. *minutifolia*
ECPO	*Echinocactus polycephalus*
ENVI	*Encelia virginensis* ssp. *actonii*
EPNE	*Ephedra nevadensis*
ERFApo	*Eriogonum fasciculatum* ssp. *polifolium*
ERIN	*Eriogonum inflatum*
EULA	*Eurotia lanata*
GAMA	*Galium mathewsii*
GRSP	*Grayia spinosa*
GUMI	*Gutierrezia microcephala*
HACO	*Haplopappus cooperi*
HALI	*Haplopappus linearifolius* ssp. *interior*
HYSA	*Hymenoclea salsola*
LATR	*Larrea tridentata*
LEFR	*Lepidium fremontii*
LYAN	*Lycium andersonii*
LYCO	*Lycium cooperi*
MATO	*Machaeranthera tortifolia*
MIBI	*Mirabilis bigelovii*
OPBA	*Opuntia basilaris*
OPEC	*Opuntia echinocarpa*
ORHY	*Oryzopsis hymenoides*
PETH	*Petalonyx thurberi*
POSC	*Poa scabrella*
SAME	*Salazaria mexicana*
SIHI	*Sitanion hystrix*
SPAM	*Sphaeralcea ambigua*
STSP	*Stipa speciosa*
STePA	*Stephanomeria pauciflora*
TESP	*Tetradymia spinosa* var. *longispina*
YUBE	*Yucca brevifolia*

Table 3. "Plant Communities" of the Mojave Desert of California recognized by Munz and Keck (1959), Jaeger and Smith (1966), Chaetham and Haller (1975), Thorne (1976), and Thorne (in press).

Munz and Keck	Jaeger and Smith	Chaetham and Haller	Thorne 1976	Thorne, in press
		Bristlecone Pine Forest	Bristlecone Pine Woodland	Bristlecone Pine Woodland
Bristle-cone Pine Forest				White fir-Pinyon Woodland
		Mountain Streams		Mountain Riparian Woodland
Pinyon-Juniper Woodland	Pinyon-Juniper Woodland	Pinyon-Juniper Woodland	Pinyon-Juniper Woodland	Pinyon-Juniper Woodland
		Mojavean Pinyon-Juniper Woodland		
Sagebrush Scrub	Sagebrush Scrub	Sagebrush Scrub	Sagebrush Scrub	Sagebrush Scrub
		Great Basin Sagebrush	Great Basin Sagebrush Scrub	Great Basin Sagebrush Scrub
			Mountain Sagebrush Scrub	Mountain Sagebrush Scrub
		Subalpine Sagebrush		Pigmy Sagebrush Scrub
		Blackbush scrub	Blackbush Scrub	Blackbush Scrub
*Joshua Tree Woodland	* Joshua Tree-High Desert Scrub	*Joshua Tree Woodland	*Joshua Tree Woodland	*Joshua Tree Woodland
Chaparral (pro parte)		Semi-desert Chaparral	Desert Transition Chaparral	Desert Chaparral
			Desert Rock Plant (Rupicoles)	Desert Rupicolous Scrub
			Non-basic Rock Plant	*Mixed Desert Scrub
			Basic Rock Plant	Desert Calcicolous Scrub
*Creosote Bush Scrub	*Creosote Bush-Low Desert Scrub	*Creosote Bush Scrub	*Creosote Bush Scrub	*Creosote Bush Scrub
		*Mojave Creosote Bush Scrub		
	Desert Sand Dunes	Active Desert Dunes	Desert Dune Sand Plant (Psammophytic)	Desert Psammophytic Scrub
		Partially stabalized Desert Dunes		
		Stabilized Desert Dunes		
		Desert Cactus Scrub	Stem Succulent Scrub	Stem-succulent (Cactus) Scrub
	* Desert Wash	Enriched Desert Scrub	Semi-succulent Scrub	
				*Desert Wash Scrub
		*Saltbush Scrub		*Saltbush Scrub
		*Mojave-Colorado Saltbush Scrub		
*Shadscale Scrub	* Shadscale Scrub	*Shadscale Scrub	*Shadscale Scrub	*Shadscale Scrub
				*Four-wing Saltbush Scrub
				*Allscale Scrub
				Desert-holly Scrub
				*Hopsage Scrub
				Gypsicolous Scrub
*Alkali Sink Scrub	*Aklali Sink	*Alkali Sink Scrub	*Aklali Sink Scrub	*Alkali Sink Scrub
		*Intermittently Moist		
		*Permanently Moist		*Alkali Meadow and Aquatic
		Alkali Seep	*Lake, Pond and Quiet Stream Aquatic	*Lake, Pond and Quiet Stream Aquatic
	Freshwater Marsh			Streamside Marsh
		*Hot Spring		
		Cold Spring		
		Desert Intermittent Rivers		
		Alkaline Lakes		
		Saline Lakes		
	Desert Urban			
	Desert Rural			

*** Communities present within the CGSA**

Total sample size (number of point intercepts per sample) averaged about 260 and ranged from 189 to 369 (with one sample receiving only 94). Transects were made by sighting on a distant object and walking in a straight line marking a point intercept at each 3-pace interval. A deliberate attempt was made to stay within a specific vegetation association, for example, sampling was discontinued if distinct changes in vegetation cover were encountered, or when arroyos with different assemblages of plants were crossed. The transects were occasionally shifted in direction, and commonly direction was reversed and a parallel transect measured around the midway point in the data gathering. One person on each team measured and called data, the other recorded data. Tape recorders were used to record data on some transects with excellent results.

From the data, species diversity is indicated by the species listed as present. Percent cover was determined for each species by dividing the number of times the species was intercepted (hit) along the transect by the total number of intercepts (hits) made in the transect. Total percent cover ranged from 10.6 to 60.6 percent and theoretically could exceed 100 percent. Absolute frequency (frequency of occurrence)was determined for each species by dividing the number of intercepts (hits) contacting that species by the number of intercepts contacting all perennial species on the transect. Absolute frequency totals 100 percent for each transect.

In selected transects additional data on absolute frequency (frequency of occurrence) was obtained by a technique developed by Harper of Utah State, consisting of recording presence of all species of perennial plants encountered along an unmarked, sighted transect ca. 5 mm wide and of unlimited length. While most of the other transects encountered 50 to 110 specimens, we could easily obtain data from 200 to 600 specimens in these transects. As the data is completely comparable to that obtained from the V-1 forms, but actually more complete due to the greater number of specimens (hits) encountered, it is reported when available in lieu of that available from the V-1 form. Its use is indicated by an asterisk near the F (F*) noting the number of hits involved (see Tables 4-10).

In addition to the above data, modal and average plant height, vigor and phenology were recorded for each perennial species; and data on slope, geomorphology, elevation, and location (USGS topographic quadrangle name, township, range, section) was recorded for each sample site, as was data on annual species diversity and phenology.

VASCULAR FLORA

A check list of all vascular plants known to occur in the CGSA, Haiwee Spring area and the Little Lake area, including both lower ponds and surrounding pastures, was assembled from collections made on the site, from herbarium and published records and from communication with knowledgeable botanists in the area.

In the checklist, species are arranged alphabetically within families, and families are arranged alphabetically within class and subclass with ferns preceding conifers, dicotyledons, monocotyledons. For each species the following data is given: Latin name with nomenclature following Munz (1974);

valid new names and combinations that have appeared in the literature since 1974 that will probably be accepted by the taxonomic community are included for appropriate species in brackets. Common names follow Munz (1974), when given, or the Illustrated Flora of the Pacific States (Abrams, 1940-1960). Growth habit, whether annual, perennial, shrub or tree, and general frequency on the CGSA site, are given. Frequencies are identified as rare (those known only from a single collection or locality), infrequent (when known from 2-5 stations), frequent (when known from 5-10 stations or more) and common (when occurring through much of the area in numerous stations). Some species are noted as being locally common while their overall distribution may be very rare. Lastly, data on habitat preferences and occurrences are noted. Naturalized species are preceded with an asterisk.

The checklist incorporates all species, subspecies and varieties known to occur outside of cultivation in the above delineated territory and is based mostly on collections and observations made on the site. Collections of vascular plants were made during April and October in 1978 and from April through July in 1979. A total of 616 collections, representing 1907 specimens was collected during this time by Henrickson and associates. These have been identified using Munz (1974). Identification of all collections was verified by Robert F. Thorne at Rancho Santa Ana Botanic Garden. A labeled set of vouchers has been deposited in the Herbarium of Rancho Santa Ana Botanic Garden, Claremont, California. Voucher specimens of the collections by Zembal, et al., in conjunction with their inventory of vascular plants and mammals of the Coso Hot Springs Area (Zembal et al., 1978) were consulted at the Rancho Santa Ana Herbarium, and their data have been incorporated into the checklist. The 1978 spring season was very wet, and several species recorded by Zembal and associates were not found during the drier 1979 spring growing season.

Mary DeDecker of Independence, California, kindly checked over the first draft of the checklist and added several records from her collections and those of Mary Ann Henry.

A total of 385 species of vascular plants is here recorded from the CGSA, Haiwee Spring and Little Lake areas. Of these only 24 (6.2 percent) are naturalized species.

RARE, ENDANGERED AND REGIONALLY ENDEMIC PLANTS

The species recorded in the above noted checklist were compared with those listed in the federal list of Endangered and Threatened Species (Federal Register, Wednesday, June 16, 1976) and the California Native Plant Society inventory of Rare and Endangered Vascular Plants of California (Powell, 1974). The distribution of each of these on the site is mapped based on herbarium, literature and personal communication references. Locally endemic plants are also noted.

RESULTS AND DISCUSSION

LITERATURE REVIEW OF VEGETATION OF THE MOJAVE DESERT AND GREAT BASIN

The terrestrial vegetation of California has recently been the subject of a review edited by Barbour and Major (1977). Several chapters apply to the CGSA, including sections by Young *et al*. (1977), which review the current status of knowledge on Great Basin Sagebush Steppe; Vasek and Thorne (1977) discuss transmontane and coniferous vegetation, and Vasek and Barbour (1977) review present knowledge on the Mojave Desert vegetation. In a series of articles, Beatley (1974, 1975, and 1976) has greatly increased our knowledge of the Mojave Desert and its transition to the Great Basin Desert. Her studies have been concentrated in central southern Nevada (Nye County) in the northeastern margin of the Mojave Desert at the Nevada (Atomic) test site (NTS) about 200 km (125 mi) east-northeast of the CGSA. Vegetative cover on the NTS is comparable to that on the CGSA, consisting of extensive areas of creosote-dominated scrub on the lower Mojave Desert slopes with Shadscale Scrub in the basins and an assemblage of species comparable to our Mixed Desert Scrub in a transition zone that continues at higher elevations into Sagebrush (*Artemisia tridentata*)-dominated scrub characteristic of the Great Basin Desert proper. At higher elevations the Sagebrush Scrub on the NTS continues into Pinyon-Juniper woodland much as it does in the Coso Mountains just north of the CGSA. Beatley was able to make a careful analysis of factors affecting vegetation zonation on the NTS as she had rainfall and temperature records over an 11-year period (1962-1972) from numerous stations on the site. Her meteorological data showed an average increase in rainfall and decrease in temperature from lower elevations in the Mojave Desert to higher elevations on the Great Basin Desert. She notes that an increase in total percent cover of shrub species correlates with increased precipitation more than with elevation (Beatley, 1975) over this transition; but as Vasek and Barbour (1977) note, this is not always a direct and uniform correlation throughout the Mojave Desert, for widely separated areas with similar average rainfall can differ greatly in total cover.

MOJAVE DESERT: The Mojave Desert is the smallest of the North American Deserts (Shreve, 1943). It ranges from the eastern slopes of the Sierra Nevada and Tehachapis east to extreme northwestern Arizona and southwestern Utah, and from the northern slopes of the San Gabriel and San Bernardino Mountains through Joshua Tree National Monument north to the Owens Valley near Big Pine, then eastward through the White Mountains across southern Nevada to southwest Utah. It covers an estimated 142,000 km^2 (60,000 m^2) and is an upland desert with elevations mostly between 610 and 1,525 m (2,000-5,000 ft) (Jaeger, 1957), with extremes at -85 m (-280 ft) in Death Valley and 3,635 m (11,918 ft) at the summit of Charleston Peak in the Spring Mountains near Las Vegas, Nevada. Rainfall comes mainly from November to March and averages 35.5-200 mm (1.4-8 in) per year). Summer thunderstorms are occasional, particularly in the eastern Mojave.

Several authors have presented classifications of vegetative cover on the Mojave Desert (Munz and Keck, 1959; Jaeger and Smith, 1966; Ornduff,1974; Chaetham and Haller, 1975; Thorne, 1976, in press). These authors usually designate vegetative classifications on floristic (taxonomic composition),physiognomic (structural)or physiographic (habitat) features or a combination of the above (e.g., Creosote Bush Scrub, Joshua Tree Woodland, Alkali Sink, etc.). Munz and Keck (1959) divided vegetative cover into major vegetation types based on physiognomic features (i.e., scrub, desert woodland, coniferous woodland) and each of these contained one or more plant communities usually designated by dominant species (e.g., Creosote Bush Scrub, Joshua Tree Woodland) or some physiographic feature (Alkali Sink). Their treatment emphasized major climatic-based communities. Minor edaphic subdivisions were not recognized. Later treatments of the Mojave Desert vegetation have recognized a greater number of communities or associations, often continuing to mix (as noted by Johnson (1976)) both habitat and floristic structural designations (e.g., Shadscale Scrub, Alkali Sink). Johnson feels plant communities should be designated by plant features, not habitat characteristics.

However as noted by Rowlands (1978) and Johnson (1976), some of these communities are based more on subjective visual assessments or intuition based on experience, rather than on any quantitative data. Most rely on a listing of indicator or important species but none substantiate the reality or consistency of these communities with quantitative data to show that the most "important" species are actually quantitatively important and not just highly conspicuous or present in the areas best known by the respective authors. Rowlands (1978) has shown that Joshua Tree Woodland does not really exist as a replicable vegetation as Joshua Tree occurs with a wide array of understory associates throughout its range and is never quantitatively dominant in a stand. Beatley (1976) based her associations on dominance, not visual aspects. She divided the Mojave Desert vegetation in the NTS into floristically determined plant associations named for the quantitatively dominant species (e.g. *Larrea-Ambrosia*; *Larrea-Lycium-Grayia*; *Larrea-Atriplex* associations, etc.). This is a highly commendable treatment but it becomes very burdensome in areas where a tight mosiac of dominants develops as it does in the CGSA. Her treatment avoids a nomenclature based on physiognomy (which was highly uniform through her area) and broadly designated plant associations *sensu* Munz and Keck (1959).

Major plant communities or associations of the Mojave Desert and pertinent to the CGSA are discussed below.

Creosote Bush Scrub: Shreve (1942) estimated that over 70% of the Mojave Desert is covered by open stands of *Larrea tridentata* (creosote bush) and *Ambrosia dumosa* (burro weed), which most would designate as a Creosote Bush Scrub association. Barbour *et al.* (1977) note this combination is the most characteristic association in the Mojave Desert. Burk (1977) reports the same for the Sonoran Desert of California. This *Larrea-Ambrosia* association is usually found on the vast intermountain bajadas and flats on loose sandy to coarse well-drained soils but avoids saline soils (Shantz & Piemeisel 1924; Marks 1950; Wallace and Romney 1972). Lunt *et al.* (1972) have shown that *Larrea* is relatively demanding on soil oxygen and may avoid some flats due to the fine-textured soils rather than

However, *Larrea* is not always associated with *Ambrosia* but may occur with shadscale (*Atriplex confertifolia*) in some plains and basins, and with hopsage (*Grayia spinosa*) or box-thorn (*Lycium andersonii*) on rocky slopes at higher elevations (Beatley 1975, 1976). Due to its large size and evergreen, dark leaves, *Larrea* is usually conspicuous even when relatively infrequent in a site as it forms a second canopy over the smaller understory associates. This often results in any area having *Larrea* being designated as a Creosote Bush Scrub association. In some of these associations, *Larrea* is quantitatively dominant and in others it is not.

Larrea tridentata is widespread in North America occurring from Queretaro-Hidalgo in central Mexico to southern Nevada. The North American species is considered disjunct from the South American Larrea divaricata (Huntziker et al., 1977). It has been the subject of numerous autecological studies on germination and survival (Sheps, 1973; Barbour, 1967, 1968; Wallace and Romney, 1972), phenology (Ackerman and Bamberg, 1974; Bamberg et al., 1973; Beatley 1974), water relations (Bamberg et al., 1973; Beatley, 1974), rate of photosynthesis and pathways (Wallace et al., 1971; Bamberg, 1975), (see review in Barbour et al., 1977; Vasek and Barbour, 1977).

The genus Larrea has recently been the subject of intensive studies through the International Biological Program (IBP); and results of some of these studies have been reported in a recent book edited by Mabry, et al. (1977), which covers both antiherbivore, natural product chemistry, vertebrate and invertebrate associations, as well as autecological and synecological data.

In the Mojave Desert, Larrea ranges from below sea-level in Death Valley usually to 4000 ft and up to 5200 feet in southerly exposures. To the south it continues into the Sonoran Desert, but its northern limit is generally considered as marking the northern limit of the Mojave Desert in California, southern Nevada and southeast Utah (Vasek and Barbour, 1977). While Larrea often forms monotonous, apparently uniform stands over plains, significant differences in composition occur. Diversity in stands increase with topographic diversity and substrate rockiness. Age structure of stands is also important (Vasek et al, 1975; Johnson 1975; Barbour et al, 1977). Density of Larrea is generally higher and more clumped in more mesic habitats. In more arid communities, Larrea is sparse and often appears to be regularly spaced (as compared to random or clumped). Woodell et al. (1969) and Barbour (1969) have presented quantitative data indicating that some populations indeed are regularly patterned. They concluded that regularity is due to interplant root competition for available water (Anderson, 1971). King and Woodell (1973) note these regular patterns may be due to elimination of younger plants in a population through intensive competition during long periods of drought.

Went (1955) considered that Larrea may secrete water-soluble toxins that remain longer in arid habitats affecting seedling establishment patterns. Knipe and Herbel (1966), Barbour (1968) and others have found no evidence of soluble allelopathic substances in Larrea that affect germination or seedling development.

Using stem height as a correlate to plant age, Barbour (1969) showed that many populations of Larrea consist of more than one size class indicating that successful establishment is an infrequent though recurring event.

In older communities, Larrea may form circular vegetative clones due to vegetative segmentation of the crown (Barbour, 1969; Vasek et al, 1975a). Sternberg (1976) verified the clonal nature of these rings estimating (through a rate established by Vasek and Johnson) a maximum of 5400 years age for one ring 7.8 m in radius. Because of cloning, identification of individual plants is difficult in density measurements.

Typical associates with Larrea-Ambrosia in the Mojave Desert include cheesebush (Hymenoclea salsola), Acamptopappus (Acamptopappus sphaerocephalus), bush peppergrass (*Lepidium fremontii*), indigo bush (*Dalea californica*, *D. fremontii*), cholla cactus (*Opuntia acanthocarpa*), beavertail cactus (*Opuntia basilaris*, Cassia (*Cassia armata*), Mormon tea (*Ephedra nevadensis*, *E. californica*), often saltbushes (*Atriplex polycarpa*, *A. confertifolia*) and Joshua tree (*Yucca brevifolia*) as well as several perennial herbs (*Eriogonum inflatum*, *Sphaeralcea ambigua*), and grasses (*Stipa speciosa*, *Oryzopsis hymenoides*) and often hopsage (*Grayia spinosa*) and winter fat (*Eurotia lanata*), etc.

At higher elevations *Larrea* is associated less frequently with *Ambrosia dumosa* and more frequently with other species as *Grayia spinosa*, *Lycium andersonii*, *Eurotia lanata*, *Tetradymia* spp., *Haplopappus cooperi*, *Yucca schidigera*, *Opuntia echinocarpa*, *Atriplex canescens*, etc. On the NTS Beatley (1975, 1976) used climatological data to show that Larrea's displacement was due to an increase in average annual precipitation more than to temperature. On the NTS *Larrea* did not occur in sites with a mean annual rainfall in excess of 183 mm (7.2 in). This limit does not hold elsewhere, however, as often sites with higher rainfall averages also have higher evaporation rates, reducing precipitation effectiveness. Other consider minimum winter temperatures to be more critical in upper limits of *Larrea* (Barbour et al 1977). Beatley(1975) and Wells and Shields (1964) consider cold air drainage to be an important factor in limiting the distribution of *Larrea* in the bottoms of basins.

Mixed Desert Scrub: At still higher elevations and along the northern border of the Mojave Desert, *Larrea* drops out entirely and we enter into what Beatley (1975, 1976) calls the Transition Desert. In the NTS this is transitional to the Great Basin Desert at still higher elevations. But this type of vegetation occurs on hills and mountains throughout the northern Mojave Desert in a zone above the limit of *Larrea* and below the limit of Pinyon-juniper woodland. Munz and Keck (1959) and Jaeger and Smith (1966) (see Table 3), gave no name to this often widespread zone. Chaetham and Haller (1975) and Thorne (1976) recognized this as part of the Blackbush Scrub but often blackbush (*Coleogyne ramosissima*) is not represented in all of this zone.

In the CGSA, we have a characteristic *Larrea-Ambrosia* association at moderate elevations up to about 1220--1350m (4000-4400 ft), usually higher on south- than north-facing slopes, and on sandy flats. This often gives way to a *Larrea-Hymenoclea-Acamptopappus* association that is called here a *Larrea-mixed* association. The "mixed" here consists of such species as *Hymenoclea salsola*, *Acamptopappus sphaerocephalus*, *Lycium andersonii*, and *Dalea fremontii*. At higher elevations *Larrea* drops out but blackbush (*Coleogyne*) does not come in. Instead there is a broad mosiac of species that are more tolerant of low mean winter temperatures than is *Larrea*. Beatley (1976) recognizes a similar series of associations, in basins where nocturnal cold air accumulates from which *Larrea* is excluded. The dominant species on the CGSA include *Hymenoclea salsola*, *Grayia spinosa*, *Eriogonum fasciculatum* ssp. *polifolium*, *Acamptopappus sphaerocephalus*, *Ephedra nevadensis*, *Lycium andersonii*, *Haplopappus cooperi*, *Dalea fremontii*, *Salazaria mexicana*, and *Tetradymia spinosa*, as well as the perennial grasses *Stipa speciosa* and *Oryzopsis hymenoides*. On the CGSA these species are present without *Coleogyne*, so designation of this vegetation as blackbush scrub is difficult.

In this report we designate this association as Mixed Desert Scrub and, as will be shown, it consists of a tight mosiac of locally dominant associations.

Thorne (in press) uses Mixed Desert Scrub for a complex of vegetation on calcareous rocky habitats in both the Mojave and Colorado Deserts of California. In his 1976 paper, Thorne called this "non-basic rock plant" (Table 3) in contrast to his calcareous rock plant association for limestone rocky areas. It also includes his semi-succulent scrub which was mainly in the Colorado Desert in 1976. Thorne also recognizes a separate Blackbush Scrub association. Vasek (personal communication) would consider the CGSA Mixed Desert Scrub as a part of the Blackbush Scrub but without blackbush. Twisselman (1967) recognized a similar zone between the Larrea and Pinyon-juniper zone which he called an Arid Scrub Association in his Kern County flora. Prigge (1975) had a similar complex in the Clark Mountains which he designated as Anomalous Desert Scrub.

In actuality what this represents is a transitional series of associations that lack dominants of other recognized associations in that it often lacks Larrea and Coleogyne, and usually lacks Joshua tree; it consists of a tight mosiac of species commonly associated with these other associations. As no one species is dominant over its total range, a taxonomic designation is not realistic. The title Mixed Desert Scrub is in reference to its physiognomy and variable composition. In the CGSA this admixture of shrubby species is a major understory association that may occur under Larrea, Joshua Tree or by itself over much of the CGSA (Figs. 1, 7).

Blackbush Scrub is not present in the CGSA. It does, however, occur just west of the CGSA above Rose Valley. Blackbush scrub itself is often considered a transition between Creosote Bush Scrub and Pinyon-Juniper Woodland and often extends into both. Vasek and Barbour (1977) note that of 185 species of vascular plants recorded throughout the range of blackbush, 68% also occur in Larrea scrub; 46% occur in Pinyon-juniper associations Only 9.2% are restricted to the blackbush zone.

On the NTS, blackbush occurs mostly between 1220 and 1525 (--1830)m [4000--5000 (--6000) ft] on rocky often limestone soils with a sandy matrix. When best developed, blackbush may form nearly pure stands with only few or no associations. Beatley (1975) notes it reaches its best development where mean annual rainfall is over 200 mm (8 in). Both mean and extreme temperatures fall within the range characteristic of Larrea zones. At its upper range Coleogyne often forms rather narrow ecotones with Great Basin Sagebush, dominated by Artemisia tridentata (Beatley, 1975, 1976).

Joshua Tree Woodland: Yucca brevifolia (Joshua tree) is perhaps the most distinctive plant in the Mojave Desert. It is an arborescent, polycarpic, monocot with rigid spine-tipped leaves borne in terminal rosettes. Unlike most monocots, it forms a distinct bark-covered trunk which increases in diameter through a distinctive meristematic zone (Simpson 1975). In photosynthesis it follows a CAM pattern (Ting et al., 1974; Johnston, 1975, 1976).

Joshua trees occur in a wide variety of habitats but appear to prefer flats and gentle bajadas with sandy, loamy or fine gravelly soils (Barbour and Vasek, 1977). Trees mostly range from 2--8 (--15) m high (Munz, 1974) bush peppergrass (Lepidium fremontii), indigo bush (Dalea californica, D. fremontii), cholla cactus (Opuntia acanthocarpa), beavertail cactus (Opuntia basilaris, Cassia (Cassia armata), Mormon tea (Ephedra nevadensis, E. californica), often saltbushes (Atriplex polycarpa, A. confertifolia) and Joshua tree (Yucca brevifolia) as well as several perennial herbs (Eriogonum inflatum, Sphaeralcea ambigua), and grasses (Stipa speciosa, Oryzopsis hymenoides) and often hopsage (Grayia spinosa) and winter fat (Eurotia lanata), etc.

At higher elevations Larrea is associated less frequently with Ambrosia dumosa and more frequently with other species as Grayia spinosa, Lycium andersonii, Eurotia lanata, Tetradymia spp., Haplopappus cooperi, Yucca schidigera, Opuntia echinocarpa, Atriplex canescens ,etc. On the NTS Beatley (1975, 1976) used climatological data to show that Larrea's displacement was due to an increase in average annual precipitation more than to temperature. On the NTS Larrea did not occur in sites with a mean annual rainfall in excess of 183 mm (7.2 in). This limit does not hold elsewhere, however, as often sites with higher rainfall averages also have higher evaporation rates,reducing precipitation effectiveness. Other consider minimum winter temperatures to be more critical in upper limits of Larrea (Barbour et al 1977). Beatley(1975) and Wells and Shields (1964) consider cold air drainage to be an important factor in limiting the distribution of Larrea in the bottoms of basins.

Mixed Desert Scrub: At still higher elevations and along the northern border of the Mojave Desert, Larrea drops out entirely and we enter into what Beatley (1975, 1976) calls the Transition Desert. In the NTS this is transitional to the Great Basin Desert at still higher elevations. But this type of vegetation occurs on hills and mountains throughout the northern Mojave Desert in a zone above the limit of Larrea and below the limit of Pinyon-juniper woodland. Munz and Keck (1959) and Jaeger and Smith (1966) (see Table 3), gave no name to this often widespread zone. Chaetham and Haller (1975) and Thorne (1976) recognized this as part of the Blackbush Scrub but often blackbush (Coleogyne ramosissima) is not represented in all of this zone.

In the CGSA, we have a characteristic Larrea-Ambrosia association at moderate elevations up to about 1220--1350m (4000-4400 ft), usually higher on south- than north-facing slopes, and on sandy flats. This often gives way to a Larrea-Hymenoclea-Acamptopappus association that is called here a Larrea-mixed association. The "mixed" here consists of such species as Hymenoclea salsola, Acamptopappus sphaerocephalus, Lycium andersonii, and Dalea fremontii. At higher elevations Larrea drops out but blackbush (Coleogyne) does not come in. Instead there is a broad mosiac of species that are more tolerant of low mean winter temperatures than is Larrea. Beatley (1976) recognizes a similar series of associations,in basins where nocturnal cold air accumulates from which Larrea is excluded. The dominant species on the CGSA include Hymenoclea salsola, Grayia spinosa, Eriogonum fasciculatum ssp. polifolium, Acamptopappus sphaerocephalus, Ephedra nevadensis, Lycium andersonii, Haplopappus cooperi, Dalea fremontii, Salazaria mexicana, and Tetradymia spinosa,as well as the perennial grasses Stipa speciosa and Oryzopsis hymenoides. On the CGSA these species are present without Coleogyne,so designation of this vegetation as blackbush scrub is difficult.

In this report we designate this association as Mixed Desert Scrub and, as will be shown, it consists of a tight mosiac of locally dominant associations.

Thorne (in press) uses Mixed Desert Scrub for a complex of vegetation on calcareous rocky habitats in both the Mojave and Colorado Deserts of California. In his 1976 paper, Thorne called this "non-basic rock plant" (Table 3) in contrast to his calcareous rock plant association for limestone rocky areas. It also includes his semi-succulent scrub which was mainly in the Colorado Desert in 1976. Thorne also recognizes a separate Blackbush Scrub association. Vasek (personal communication) would consider the CGSA Mixed Desert Scrub as a part of the Blackbush Scrub but without blackbush. Twisselman (1967) recognized a similar zone between the Larrea and Pinyon-juniper zone which he called an Arid Scrub Association in his Kern County flora. Prigge (1975) had a similar complex in the Clark Mountains which he designated as Anomalous Desert Scrub.

In actuality what this represents is a transitional series of associations that lack dominants of other recognized associations in that it often lacks Larrea and Coleogyne, and usually lacks Joshua tree; it consists of a tight mosiac of species commonly associated with these other associations. As no one species is dominant over its total range, a taxonomic designation is not realistic. The title Mixed Desert Scrub is in reference to its physiognomy and variable composition. In the CGSA this admixture of shrubby species is a major understory association that may occur under Larrea, Joshua Tree or by itself over much of the CGSA (Figs. 1, 7).

Blackbush Scrub is not present in the CGSA. It does, however, occur just west of the CGSA above Rose Valley. Blackbush scrub itself is often considered a transition between Creosote Bush Scrub and Pinyon-Juniper Woodland and often extends into both. Vasek and Barbour (1977) note that of 185 species of vascular plants recorded throughout the range of blackbush, 68% also occur in Larrea scrub; 46% occur in Pinyon-juniper associations Only 9.2% are restricted to the blackbush zone.

On the NTS, blackbush occurs mostly between 1220 and 1525 (--1830)m [4000--5000 (--6000) ft] on rocky often limestone soils with a sandy matrix. When best developed, blackbush may form nearly pure stands with only few or no associations. Beatley (1975) notes it reaches its best development where mean annual rainfall is over 200 mm (8 in). Both mean and extreme temperatures fall within the range characteristic of Larrea zones. At its upper range Coleogyne often forms rather narrow ecotones with Great Basin Sagebush, dominated by Artemisia tridentata (Beatley, 1975, 1976).

Joshua Tree Woodland: Yucca brevifolia (Joshua tree) is perhaps the most distinctive plant in the Mojave Desert. It is an arborescent, polycarpic, monocot with rigid spine-tipped leaves borne in terminal rosettes. Unlike most monocots, it forms a distinct bark-covered trunk which increases in diameter through a distinctive meristematic zone (Simpson 1975). In photosynthesis it follows a CAM pattern (Ting et al., 1974; Johnston, 1975, 1976).

Joshua trees occur in a wide variety of habitats but appear to prefer flats and gentle bajadas with sandy, loamy or fine gravelly soils (Barbour and Vasek, 1977). Trees mostly range from 2--8 (--15) m high (Munz, 1974) but McKelvey (1938) reports one measured in 1935 with a height of 24 m (80 ft) and a diameter of 2.7 m (9 ft) (see Rowlands, 1978). Growth rates are apparently slow. Vasek (1973) reports a height increase of 9 cm/year for a plant in Rose Mountain in San Bernardino County. Rowlands (1978) reports an average trunk diameter increase of 0.7 cm/year for the same plant.

Munz (1959, 1974) recognizes three varieties of Joshua tree, none of which is accepted by Reveal in the Great Basin Flora (Cronquist _et al._, 1977). Rowlands (1978), who has made an extensive study of the vegetative dynamics of _Yucca brevifolia_ recognizes two varieties. _Yucca brevifolia_ var. _jaegeriana_ is characterized by true dichotomous branching (Simpson 1975; Rowlands 1978) and usually branches 4--10 dm above the base. It has a more eastern range in areas receiving a greater percentage of summer rainfall (Rowlands 1978) and occurs from the Avawatz Mountains in northern San Bernardino County to southern Nevada, from extreme southwestern Utah south to west-central Arizona. _Yucca brevifolia_ var. _brevifolia_ is characterized by monopodial or pseudodichotomous branching in that it branches or forks only after flowering disrupts the apex and typically has a straight trunk for the first 20 dm. It occupies the western portion of the species range, from near Gorman in Los Angeles County across the Antelope Valley to Joshua Tree National Monument, north through the central and western Mojave to the southeastern slopes of the White Mountains, into the Great Basin of Nevada. _Yucca brevifolia_ var. _herbertii_ which has been distinguished by its tendency to form clumps or clones from scaley underground rhizomes is reported (Munz, 1974) from the Antelope Valley north to Kern County. It is also present on the CGSA. As Rowlands (1978) indicates, the cloning tendency may be due to increased water availability coupled with a short growing season, as he noted cloning increased with elevation. He justifiably considers var. _herbertii_ to be synonymous with var. _brevifolia_. Both Simpson (1975) and Rowlands (1978) have noted that clones also are found occasionally in var. _jaegeriana_.

Throughout its range Joshua tree occurs from 600 to 2200 m (2000--7200 ft) elevation in areas averaging between 110 and 280 mm (4.4--11 in) rainfall a year (Rowlands 1978). Rowlands (1978) also found that maximum summer and minimum winter temperatures also have controlling influences on its distribution.

The presence of Joshua trees usually is considered indicative of a Joshua Tree community which is widely recognized as a discrete community in the southwest United States (Tidestrom 1925; Munz & Keck 1959; Jaeger & Smith 1971; Ornduff 1974; Thorne 1976, in press). This is primarily because Joshua trees usually visually dominate the landscape due to their arboreal and distinctive habit. More recently others (Bradley and Deacon, 1967; Randall, 1972; Kornoelje, 1973; Vasek and Barbour, 1977; Rowlands, 1978) have noted Joshua Tree Woodland does not exist as a uniform vegetation community, and when present Joshua tree is more visually than numerically dominant. Rowlands (1978) has looked at this question directly and has quantitatively sampled 20 stands of Joshua tree across its broad spatial and elevational range. He found Joshua trees associated with a wide diversity of understory components. These include associations commonly referred to as Creosote Bush Scrub with _Larrea-Ambrosia_[1], _Larrea-Acamptopappus_, _Larrea-Yucca baccata_, Xerophytic Saltbush Scrub, Desert

---

[1] Dominant-subdominant species in stands.

Grassland or Shrub-steppe with *Hilaria rigida-Ephedra nevadensis*, *Hilaria-Artemisia tridentata*, *Hilaria-Yucca schidigera*, *Hilaria-Salazaria*, *Hilaria-Eriogonum pumilis*, Shadscale Scrub with *Atriplex confertifolia*, Blackbush Scrub with *Coleogyne-Lycium pallidum*, *Coleogyne-Larrea*, *Coleogyne-Yucca baccata*, *Thamnosma montana-Ephedra*, *Tetradymia glabrata-Gutierrezia microcephala* as well as Sagebush Scrub, Pinyon-Juniper Woodland with *Pinus monophylla-Juniperus* ssp., and Desert Chaparral. Of the above it most commonly occurs with grasses and blackbush. In no case did the Joshua tree contribute much to the total community composition either in terms of absolute cover or frequency. The highest percent cover recorded for Joshua tree by Rowlands (1978) was 10.1 percent in an area in Arizona; however, the average cover recorded in his 20 samples was only 2.9 percent. The highest density recorded was in southern Nevada (Lee Canyon) with 450 trees/ha however these trees were small and estimated crown cover was only 3.1 percent (Rowlands 1978). In none of the samples was Joshua tree numerically dominant. I agree with the conclusions of Rowlands (1978) that Joshua Tree Woodland is not a valid community but represents an over-emphasis of the visual dominant. Neither Beatley (1976) nor Twisselmann (1967) recognized a Joshua Tree Woodland community, even though it formed locally extensive populations in their respective study sites.

Alkali Sink Scrub: Vegetation around dry lake beds or playas, sinks and seeps where available ground water is often saline or alkaline usually consists of a few species of plants that can tolerate these local edaphic conditions. Vasek and Barbour (1977) consider this a wet or halophytic phase of a Saltbush Scrub that also has a xerophytic phase on dry habitats as many species are associated with both habitats. These habitats may be either saline, i.e. having soluble salts in such quantities as to interfere with growth of plants (U.S. Salinity Laboratory, 1954) or alkaline, having a basic or alkaline pH. Alkali soils are defined as those with enough exchangeable sodium to interfere with growth of plants. Saline soils are often alkaline. Flats and seeps can be saline or alkaline or both.

Most authors (Table 3) recognize Alkali Sink Scrub association. Jaeger and Smith (1966) use a physiographic name, Alkali Sink. Chaetham and Haller (1975) divide Alkali Sink Scrub on the basis of water permanency (i.e., intermittently or permanently moist Alkali Sink) and they recognize a separate Alkali Seep. In the Mojave Desert these habitats often contain such species as iodine bush (*Allenrolfea occidentalis*), seep weed (*Suaeda* spp.), *Sesuvium verrucosum*, *Heliotropium curassavicum* var. *oculatum*, *Kochia* spp., *Nitrophila occidentalis*, *Atriplex* spp., *Sarcobatus vermiculatus* and salt grass (*Distichlis spicata* var. *stricta*), etc. (Thorne, 1966; in press).

Around seeps and marshes where saline or alkaline soils develop more hydric habitats one finds an Alkali Seep (Chaetham and Haller, 1975) or an Alkali Meadow and Aquatic (Thorne, in press) community consisting of such species as *Distichlis spicata* var. *stricta*, *Juncus mexicanus*, *J. cooperi*, *Phragmites australis*, and species of *Scirpus*, *Carex*, *Eleocharis*, as well yerba mansa (*Anemopsis californica*). In some areas a distinct submersed aquatic phase, consisting of species of *Najas*, *Potamogeton*, *Ruppia*, *Zannichellia*, etc., occurs. On the CGSA these types of habitats occur around Little Lake. Bradley (1970) has described the wet meadow vegetation around Saratoga Springs in southernmost Death Valley National Monument. Beatley (1976) has described similar vegetation around Ash Meadows in adjacent Nevada.

Saltbush Scrub: Saltbush Scrub is considered by Vasěk and Barbour (1977) as a more xeric phase of Alkali Scrub as they share several common species. Saltbush scrub develops in dried, often finer-textured (heavier), sometimes slightly saline or alkaline soils in depressions, on flats, slopes and peripheral to alkali sinks where edaphic conditions restrict growth of more sensitive species.

Beatley (1975, 1976) has shown that cold air drainage can also be important in restricting less tolerant species from open or closed basins. Saltbush Scrub is largely dominated by various, mostly silver-leaved species of Atriplex. It is divided by Chaetham and Haller (1975) into Valley, Mojave, and Great Basin phases (Table 3). Thorne (in press), at the suggestion of Johnston (1976), divides his Saltbush Scrub into several subtypes, dependent on local dominants: e.g., Four-winged Saltbush Scrub with Atriplex canescens, Allscale Scrub with A. polycarpa, Desert Holly Scrub with A. hymenelytra, Hopsage Scrub with Grayia spinosa. He includes among these the widely recognized Shadscale Scrub, dominated by Atriplex confertifolia.

But throughout the Mojave Desert, Saltbush Scrub may be dominated by any one of the above species or a mixture of these species. Hopsage (Grayia) also may form dominant stands in Mixed Desert Scrub through the northern Mojave. In many areas these species will develop distinct stands on flats or slopes where no apparent edaphic change is discernible. Species such as Atriplex polycarpa and A. canescens are quite polymorphic and will develop in a wide variety of habitat types, some saline, others not; sometimes in high density, at other times not. It becomes difficult to use these species as consistant indicators of a viable association.

In the CGSA two species commonly considered as important phases of Saltbush Scrub are dominant in small to extensive areas. In addition the widespread Shadscale Scrub is well developed on the site.

The four-winged saltbush (Atriplex canescens) is a rather conspicuous grayish-green dioecious shrub 4--20 dm high and often as wide. It is the most widely distributed of the shrubby Atriplexes (Hitchcock et al., 1964), ranging from eastern Washington to Alberta, Canada south into Baja California, Texas, and central Mexico. It is widely distributed in California, ranging from -60 m (-200 ft) near the Salton Sea and in Death Valley to over 2100 m (7000 ft) in several plant communities (Thorne, in press). It has a C4 (Krantz) photosynthetic pathway (Wallace et al., 1971; Johnson, 1976) and is active during the summer months, flowering in spring and fruiting in the fall.

In Death Valley, Hunt (1966) regards it to be a phreatophyte tolerant of some soil salinity. Atriplex canescens is often common around springs and seeps and in basins or depressions-- areas subjected to cold air drainage (Beatley 1975, 1976). On the NTS it occurs in a variety of habitats, including basins receiving cold air drainage, around springs and in deep sandy soils, often mixed with Grayia and Lycium (Beatley 1976).

In the CGSA, Atriplex canescens is dominant, mostly in very local depressions or rather large basins, probably affected by both cold air drainage and soil texture differences. Whether salinity is an important factor on the CGSA is not known. Atriplex canescens is also locally common around the margins of the seepage below Haiwee Spring and is conspicuous on some cinder cones.

Allscale (Atriplex polycarpa) is another species commonly considered an indicator of Saltbush Scrub and when dominant would constitute Thorne's (in press) Allscale Scrub. It is a distinctive, rounded, intricately-branched, microphyllous, light gray-colored shrub 3--10 (--18) dm high which also exhibits a C4 (Krantz) photosynthetic pathway (Johnson 1976). It occurs from Baja California and Sonora (Mexico) north to Utah, and through southeastern California to the southern San Joaquin and Owens Valleys. It is commonly found in saline habitats but also can form extensive stands on sandy to silty loams or on gravel fans (Thorne in press, Hunt 1966). Over its range it exhibits an altitudinal range of ca.-60 to 1500 m (-200 to ca.5000 ft).

Sankary and Barbour (1972) have published an autecological study of allscale from the southern San Joaquin Valley. They indicate that the once wide distribution in the area has been greatly reduced by grazing. It is now restricted to saline and fenced areas. They note germination may be high, but establishment may be reduced through competition with introduced annuals as Bromus rubens and Erodium cicutarium. Allscale can tolerate up to 5% salinity.

GREAT BASIN: Although the CGSA contains only Mojave and Transition Desert vegetation (sensu Beatley, 1975, 1976), the NTS continues into the Great Basin Desert proper. Vegetation of the Great Basin Desert is briefly discussed here to allow a better understanding of our transitional environments. These communities consist primarily of Great Basin Sage dominated by Artemisia tridentata on the slopes above 5,000 ft, and Pinyon-Juniper Woodland and occasionally White Fir Zones at respectively higher elevations. Shadscale occurs in the lower basins. Reviews of the Great Basin vegetation are given by Beatley (1976), Cronquist et al. (1972), and in part by Young et al. (1977).

Great Basin Sagebrush: Artemisia tridentata is a dominant association through much of the Great Basin (Fenneman, 1931; Billings, 1951; Cronquist et al., 1972) and extends from British Columbia through the Rocky Mountains into northern Mexico. It occurs mostly on deeper sandy soils of variable derivations on flats and bajadas, mostly above 1500 m (5000 ft). At its lower range it forms broad transitions with Coleogyne, Grayia-Eurotia associations. It forms more restrictive transitions above shadscale-dominated basins with cold air drainage (Beatley 1976). At 1800 m (6000 ft) it forms a broad transition with Pinyon-Juniper Woodland and continues in some mountains up to 3050 m (10,000 ft) (Cronquist et al., 1972).

Beatley (1976) notes that sagebrush zones on the NTS are characterized by higher rainfall, lower yearly and night-time temperatures and, in some sites, higher daytime temperatures than Mojave Desert communities. Rainfall comes mainly in the winter but growth occurs during a short period in late spring and is terminated by low soil moisture in the summer (Evans, 1970; Young et al., 1977).

In sagebrush zones, Artemisia tridentata is usually strongly dominant. Beatley (1976) reports a sagebrush frequency of 95% in an area with 35% cover. Shrub associates include a number of shrubs as Eurotia lanata, *Chrysothamnus*, *Ephedra*, *Grayia*, and many perennial herbs. Bunch grasses (*Agropyron*, *Poa*, *Festuca*, *Bromus*, *Oryzopsis*, *Elymus*, *Sitanion*, *Stipa*) are often common, sometimes dominant (Young et al., 1977; Beatley,1976) in Sagebrush Scrub, but these are commonly drastically reduced by grazing (Christensen and Johnson,1964) and overtaken by the aggressive, unpalatable, drought-resistant sagebrush (Robertson,1947; Christensen,1959). Perennial grasses are not uniformly dense over the sagebrush zone but appear to be more prominent where rainfall is higher and mostly in the summer (Christensen, 1959). Annual herbs are often not well represented due to low temperatures which limit germination in most years (Beatley,1976). In some areas the introduced chess grasses (*Bromus rubens*, *B. tectorum*) have become established creating fire hazards (Harris 1967).

Pinyon-Juniper Woodland: As noted, above 1,830 m (6,000 ft), Sagebrush forms broad transitions and an understory initially with Utah juniper (*Juniperus osteosperma*) and at slightly higher elevations with Pinyon pine (*Pinus monophylla*) to form often very open woodlands up to ca.2500 m (8000 ft) (Billings,1954). At lower elevations the pinyon and/or junipers are confined to slopes and ridges where sagebrush prevails, but at higher elevations they form extensive though open woodlands across plains with an understory of scattered sagebrush, and species of *Ceanothus*, *Cercocarpus*, *Opuntia*, *Tetradymia*, etc. and perennial herbs and grasses (*Stipa*, *Agropyron*, *Bouteloua*, *Poa*, *Sitanion*). Rainfall in this zone commonly averages 10--12 inches or more annually with much of the precipitation coming as snow. Temperatures are cooler at this altitude giving a favorable precipitation effectiveness.

Pinyon-Juniper Woodlands also extend into the mountains of the Mojave Desert (Vasek and Barbour, 1977) and occur in the Coso mountains just north of the CGSA, beginning at ca. 1,800 m (6,000 ft), but not on the CGSA. They are also present in the Inyo, Panamint, Argus, Grapevine, Last Chance, Kingston, Avawatz, Clark, New York, Providence, Granite, Old Woman and Coxcomb Mountains and along the north slopes of the San Bernardino and San Gabriel Mountains (Vasek and Thorne, 1977).

On exposed high mountain slopes at 2440--3050 m (8000--10,000 ft), pinyon-juniper may drop out to be replaced by an understory of *Artemisia tridentata* which is continuous from the sagebrush scrub below. This will often occur with grasses or shrubs such as *Cercocarpus ledifolius* to form dense low scrub giving rise to "bald" mountains (Billings,1951; Cronquist, et al.,1972;Beatley,1976). In other areas Pinyon-Juniper Woodland is replaced over a narrow transition zone by white fir (*Abies concolor*) first in canyons at ca.2100 m (7000 ft) and on montane slopes at about 2440 m (8000 ft). In some canyons, yellow pine (*Pinus ponderosa*) may be associated with white fir (Cronquist et al.,1972;Beatley 1976) as in the Charleston-Spring Mountains (Clokey,1951). In other ranges pinyon-juniper (rarely white fir zones) are replaced by limber pine (*Pinus flexilis*) (mostly in the north) or bristlecone pine (*Pinus longaeva*) (in the south), which extends up to timberline at 3050--3400 m (10,000--11,000 ft) (Vasek and Thorne, 1977). In the Mojave Desert of California, white fir is known from the Kingston, Clark, and New York Mountains (Vasek and Thorne,1977; Griffin and Crutchfield,1972).

HUMAN IMPACTS ON DESERT ENVIRONMENTS: Several recent papers have begun to look at the impact of specific disturbances on the Mojave Desert.

Davidson and Fox (1974) analyzed the effects of off-road vehicular racing and parking-assembly areas in Creosote Bush Scrub in northern Kern County, noting the changes in herbaceous and shrub cover as well as the effects on soil compaction. Their data shows a general decrease in vegetative cover, particularly in herbaceous cover. They briefly discuss the consequences of soil compaction.

Stebbins (1974) has presented a thorough discussion on the impact of off-road vehicles in the California Deserts. He outlines the role that BLM has had in attempting to regulate their consumptive use of these resources.

Vasek et al. (1975) have studied the regeneration of vegetation where disturbed by pipeline construction in a Creosote-_Ambrosia_ _dumosa_ Scrub in Lucerne Valley. They note that after 12 years' disturbance, long-lived perennials (which they use as an indication of long-term successful regeneration, as compared to regeneration by short-lived pioneers) comprised 0 to 41 percent of the ground cover as compared to 25 to 100 percent for these same species on adjacent undisturbed sites. Judging from the age of some shrubs such as _Larrea_, they concluded that complete recovery from such disturbance may be measured in centuries, not decades.

Recovery of Creosote Bush Scrub under powerlines constructed 5 and 33 years previously were also studied in the same area (Vasek et al., 1975). They again found a slight enhancement of long-lived perennial vegetation along roadways. Surprisingly they also noted a slight increase in long-lived perennial vegetation under the powerline wires which they conjectured may be due to accumulation of moisture from condensation on the wire. Recovery under the pylons themselves, where disturbance was the greatest, was variable but usually low after 5 years, but "significant though not complete after about 33 years".

Highway and roads result in a complete elimination of natural habitats and cause a shift in the distribution patterns of rainfall. This shift in water resources from both rainfall and from concentration of upward capillary movement has a strong effect on vegetation patterns. Johnson et al. (1975) note an edge effect along paved roads increases adjacent productivity about 17 times over that of adjacent sites outside the road's influence. Even when the barren road surface was considered as part of the entire productive unit the area showed an increase in productivity of approximately six times that of adjacent undisturbed areas. Unpaved roads also show increases in total plant biomass of more than six percent when comparing both roadside and roadbed with undisturbed areas. In each case diversity, plant cover, and total biomass were enhanced by the presence of roads. This is due mostly to the increase in size (biomass) of mature perennial species such as _Larrea_ and _Ambrosia_ which receive more water and have less competition because of the lack of plants in the roadway. Roadways also present habitats for invasion of exotic species (Frenkel, 1970) and represent significant invasion corridors for exotic weed species.

SUMMARY: CGSA ASSOCIATIONS

The CGSA has a wide diversity of physical habitats and contains many of the associations known from the Mojave Desert (Table 3). Though the CGSA lies in the northeastern portion of the Mojave Desert, it contains components of the Mojave Desert and Transitional vegetations similar to those found on the NTS by Beatley (1976). These transitional components occur at higher elevations on the site and would here be transitional to the Pinyon-Juniper Woodlands on the Coso Mountains to the north.

The CGSA has a number of recognizable plant associations, some dominated by one species (_Atriplex canescens_, _A. polycarpa_, _A. confertifolia_) others by a number of species (Mixed Desert Scrub). Sometimes these associations have discrete borders, more often they greatly overlap. Some are components of the understory, while others (_Larrea tridentata_, _Yucca brevifolia_) form a distinct second story and spread over several of the understory scrub components. Because of this it is very difficult to divide the vegetation on the CGSA into distinct vegetational units. As noted previously, the vegetational map (Fig. 1) is composed of a series of often overlapping distributions of several component species or species associations, as follows:

1. _Atriplex confertifolia_
2. _Atriplex polycarpa_
3. _Atriplex canescens_
4. _Chrysothamnus nauseosus_
5. _Ambrosia dumosa_
6. Mixed Desert Scrub
7. _Larrea tridentata_
8. _Yucca brevifolia_
9. Disturbed, cultivated, open and barren areas.

The distribution of each of these components is mapped separately as well (Figs. 3-10). These component species and associations, when combined into a vegetation map (Fig. 1), give a somewhat improved perspective of the true vegetative continua that are actually present. However, the map is still highly generalized, and the true extent of the great overlap of these components is in actuality not really represented.

Annuals are discussed separately, below.

ANNUALS: Annuals are an additional important component of desert vegetation. The Mojave Desert has both winter and summer annuals (Vasek and Barbour, 1977). Winter annuals germinate with the rains from late September to December, grow as rosettes during the cold winter months, and undergo stem elongation and flowering the following spring from March to May or into June at higher elevations (Beatley, 1969). They perish with summer drought. Density and development of winter annuals is dependent on the amount and presence of the autumn rains and will vary greatly from year to year. If autumn rains are absent, density of winter annuals will be greatly reduced. Some germination will follow spring rains (Beatley, 1969). If autumn rains exceed 25 mm (1 in), winter annual populations will be large ; if rains are only 15--25 mm in the autumn, annuals the following spring are more scattered. Mortality due to herbivory is usually small (Beatley, 1967). Highest mortality comes from drought stress as plants begin to elongate in preparation for flowering in the spring. In the NTS, Beatley found winter annual densities ranged from 0 to ca. $1000/m^2$, with a maximum cover of 30% and a biomass up to ca. 600 kg/ha. Patterns of distribution of winter annuals were described by Went (1948). Some species tend to occur under shrubs, other occur mostly between the shrubs. Muller (1953), Muller and Muller (1956), and Adams et al. (1970) have discussed associations of annuals with shrubs and water-repellent soils.

In contrast to winter annuals, a few summer annuals also occur in the Mojave Desert. Germination of these species occurs after summer-fall rains and they flower in the late summer until the first frosts--a life cycle of only a few weeks. All these species have a C_4 (Krantz) photosynthetic pathway (Johnson, 1976; Vasek and Barbour, 1977). These include species of Mollugo, Amaranthus, Pectis, Atriplex, Salsola, Euphorbia, Allionia, Boerhaavia, Aristida, Bouteloua, Erioneuron, Portulaca, Kallstromia, and Tribulus. They are not well represented in the CGSA.

Beatley (1969, 1976b) provided some quantitative data to substantiate that reproductive success in desert rodents is dependent on the presence of winter annuals, which in turn is dependent on autumn (or spring) rains. Though these rodents are primarily seed eaters and can survive solely on these resources, dietary water and nutrients and vitamins obtainable from green vegetable matter may be necessary for the initiation of the reproductive cycle and successful rearing of litters and lactation. A lack of vernal annuals is directly correlated with a lack of reproductive success and population decline.

A total of 201 species of annuals occur on the arid portions of the CGSA; two additional weedy species were collected below Haiwee Spring. This constitutes 52.7 percent of the entire flora of the CGSA. The largest concentrations of annuals occur in sandy habitats, mostly on the basin floors as in Rose Valley. Annuals are less common at higher elevations in the CGSA, but there they are notably more common on southern exposures. No attempt is made here to indicate the relative abundance of each species in each vegetation association on the site as their presence is more correlated with substrate and elevation than perennial-shrub association.

QUANTITATIVE DATA ON VEGETATION

ATRIPLEX CONFERTIFOLIA: Atriplex confertifolia is dominant over about 53.6 km^2 (20.7 mi^2) or 18.2 percent of the CGSA both in depressions and basins as in Rose Valley, and in the valleys north and east of Sugarloaf Mountain and on open sandy-pebbly slopes and ridges south and northwest of Cactus Peak (Figs. 1, 3). Twenty-seven stands were quantitatively sampled (Fig. 3;Table 4).[1] Data in Table 4 is separated into 3 classes: 1) samples clearly dominated by shadscale with absolute frequencies in excess of 65 percent (9 stands); 2) samples in which shadscale is not numerically dominant but associated with many other species that continue into Mixed Desert Scrub; on these stands absolute frequencies of shadscale lie below 55 percent (10 stands); 3) areas dominated by Artemisia spinescens (bud sagebrush) usually in association with shadscale (8 stands).

The first two classes are quite artificial in that the distribution of associates forms a mosaic pattern, sometimes in association with changes in surface drainage patterns and at other times quite independent of any apparent edaphic change.

In the first two classes, substrate consists mostly of well-drained coarse to fine sands with a silty matrix. Those in Rose Valley showed little surface rockiness, but on more exposed slopes and ridges the substrate had a well-developed surface of desert pavement of small rocks. Average substrate cover for the combined 19 stands consisted of 46 percent (15.7--73.8%) bare ground, 29 percent (17.2--39.6%) litter, 24 percent (0--51.0%) small rocks and 1 percent (0--4.4%) large rocks.

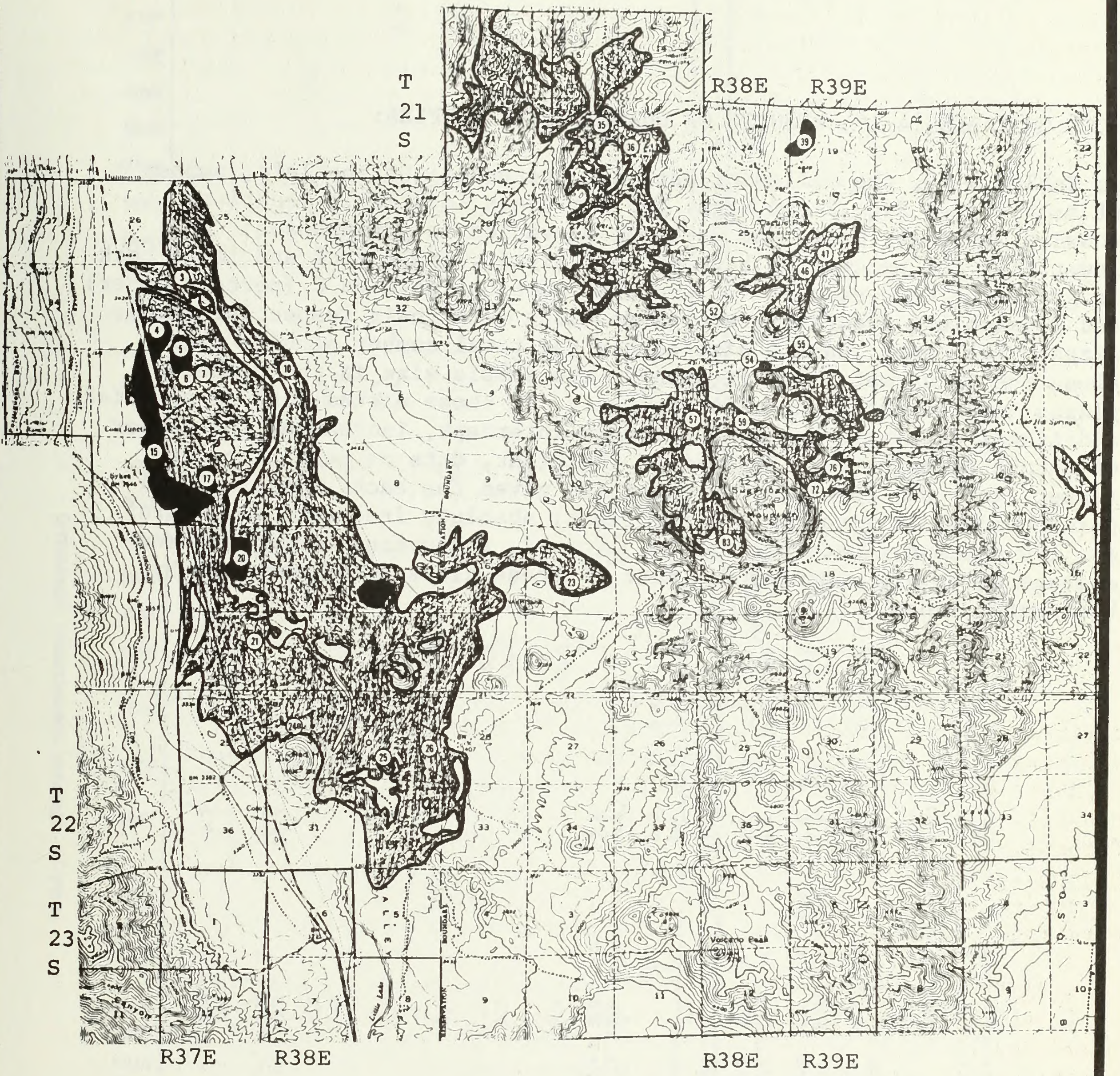
1) Shadscale Association: Atriplex confertifolia is numerically dominant over a portion of the Rose Valley basin but over most of the basins and ridges around Sugarloaf and Cactus Peak. The 9 stands sampled average 23.3 percent cover (range 19.6--36%) of which Atriplex confertifolia constitutes 18.6 percent cover (15.5--22.8%) with an average absolute frequency of 73.5 percent (63.4--88.3%). Most common associates include Hymenoclea salsola in 8 of 9 samples and Oryzopsis hymenoides in 7 of the 9 samples and Lycium andersonii in 5 of 9 samples. A total of 6 species were recorded as associates in these stands mostly in small amounts.

2) Shadscale-Mixed Association: In many areas, Atriplex confertifolia while still retaining the highest cover of any species, is associated as Mixed Desert Scrub. These Mixed-Shadscale stands are common in but not restricted to Rose Valley. Total percent cover for the 10 stands sampled averaged 27.0 percent (range 16.3--34%) which was higher than the more pure stands above. Atriplex confertifolia contributed on the average only 11.2 percent cover (4.9--18.3%) and had an average absolute frequency of only 38.9 percent (23.6--54.1%). Most common associates included Hymenoclea salsola and Acamptopappus sphaerocephalus, present in all 10 stands, sometimes with a higher percent cover than shadscale (see Sample 27). Grayia spinosa occurred in 9 of 10 stands and Eurotia lanata, Lycium andersonii and Oryzopsis hymenoides occurred in 8 of the 10 stands. A total of 23 perennial associates were recorded from these stands.

The separation of shadscale-dominated and shadscale-mixed associations above is not meant to imply the presence of two distinct vegetational assemblages but it merely indicates that in some areas species characteristic of Mixed Desert Scrub will overlap with Shadscale. In Rose Valley the change

---

[1] See note on page VI-26 regarding data in Tables 4-10.



EXPLANATION

Distribution of Atriplex confertifolia (shadscale), shaded, and Artemisia spinescens (bud sage), solid, in the CGSA. Sample sites are indicated by numbers. See Table 4 for data.

Figure 3. DISTRIBUTION OF SHADSCALE AND BUD SAGE

NOTE ON TABLES 4-10, RESULTS OF QUANTITATIVE SAMPLES:

In Tables 4-10, the following data are presented: On the left, number of sample (see Fig. 2 and Figs. 3-9 for exact location); location showing Township, Range and Section; elevation in parentheses; in lower line the percent of bare ground, litter, small rock and large rock is given for each sample. In the next section, data on C (percent cover) and F (absolute frequency) are given along with their respective sample sizes. For cover, sample size equals the total number of hits taken along the intercept. For frequency, the sample size is the number of plants intercepted along this transect. In those marked with an asterisk, additional data were taken on a longer intercept, increasing the number of shrubs encountered. Further to the right, data on percent cover (upper line) and absolute frequency are given for each sample. Total percent cover is given on the far right; absolute frequency will total ca. 100 percent. Data are usually grouped, and average substrate and average cover are computed for most of these classes and demarked by horizontal lines.

TABLE 4: ATRIPLEX CONFERTIFOLIA (SHADSCALE)

Number	(Location) Bare Ground	Litter	Sm. Rock	(Elev.) Lg. Rock	DATA	SAMPLE	ATCO	ARSP	ATPO	HYSA	GRSP	LATR	ACSP	EULA	STSP	ORHY	TESP	AMDU	LYAN	EPNE	MIBI	DAFR	YUBE	LEFE	MATO	GUMI	OPEC	OPBA	STePA	LYCO	HACO	ATCA	ASLE	SPAM	DEAD	PERCENT COVER
SHADSCALE ASSOCIATION																																			
6	T22S;	R37E;	S1.	(3380')	C	301	15.6	0.7	-	0.3			0.7	0.3		0.7	1.0		1.3																4.0	24.6
	67.5;	32.5;	0;	0	F	75	63.5	2.7		1.3			2.7	1.3		2.7	4.0		5.3																16.2	
26	T22S;	R38E;	S29.	(3360')	C	270	16.2		0.7	1.5			4.4					0.4	0.7																	23.9
	60.9;	34.1;	3.8;	1.2	F	65	67.6		3.1	6.2			18.5					1.5	3.1																	
47	T21S;	R39E;	S30.	(5000')	C	193	18.1			1.0				-	-	-			-		-		2.6				0.5		-	-						22.3
	25.0;	31.2;	43.8;	0	F*	237	74.3			17.3				1.3	3.0	0.8					0.4		0.8													
46	T21S;	R39E;	S30.	(4850')	C	206	22.8			-					-	0.5			-				1.9		-								-			25.2
	25.2;	39.6;	35.1;	0	F*	238	71.0			0.8					13.0	5.0			0.4				0.4		0.4								8.8			
52	T21S;	R38E;	S36.	(4500')	C	197	17.8			-		1.0				0.5		-	-		-												-			19.3
	32.5;	28.4;	38.7;	0.5	F*	264	78.4			0.4		12.1				1.5		4.9	0.4		0.4												0.4			
57	T22S;	R38E;	S2.	(4130')	C	189	19.1			-						0.5																				19.6
	30.9;	17.2;	51.0;	1.0	F*	213	88.3			0.5						11.2																				
59	T22S;	R38E;	S1.	(4120')	C	189	19.6			-						-																		-			20.1
	22.5;	27.8;	48.1;	1.6	F*	213	73.7			0.5						15.5																	10.3			
72	T22S;	R.9E;	S7.	(4200')	C	261	22.6		0.4	5.0	0.4		3.5						1.1	0.4		1.9								0.4						36.0
	30.6;	35.3;	34.1;	0	F	93	63.4		1.1	12.9	1.1		9.7						3.2	1.1		5.3								1.1						
83	T22S;	R38E;	S12.	(4440')	C	330	15.5	0.3			1.2		0.3	0.3	0.6	0.3																				18.5
	42.3;	24.0;	32.8;	0.9	F	61	83.6	1.6			6.6		1.6	1.6	3.3	1.6																				
Average Substrate					Average Cover																															
	37.5;	30.0;	31.9;	5.8			18.6	0.1	0.1	0.9	0.2	0.1	1.0	0.1	0.1	0.3	0.1		0.1	0.3	0.1	0.2	0.5				0.1			0.1					0.4	23.3
SHADSCALE-MIXED ASSOCIATION																																			
7	T22S;	R37E;	S1.	(3382')	C	292	11.3		3.4	8.2			1.7	0.3	1.3	1.2	1.3	1.3	1.0									-		0.3					2.7	34.0
	64.3;	34.2;	1.4;	0	F	99	33.3		10.1	24.2			5.1	1.0	4.0	3.0	4.0	4.0	3.0																8.1	
10	T22S;	R38E;	S6.	(3380')	C	251	7.9		0.4	2.0	0.4	0.8	3.6	0.4		0.8		0.4																0.4		20.7
	75.8;	19.4;	4.4;	0.4	F	52	38.5		19.6	9.6	1.9	3.8	17.3	1.9		3.8		1.9																1.9		
21	T22S;	R37E;	S24.	(3360')	C	310	6.8		2.6	13.5	0.3		1.9	0.6	0.3	1.6	-	-	1.0	-								-		-					2.7	34.0
	71.6;	27.1;	1.0;	0.3	F	89	23.6		9.0	47.2	1.1		6.7	2.3	1.1	5.6			3.4																	
23	T22S;	R38E;	S15.	(3700')	C	278	18.3	2.8		-	-	4.3	0.4					3.9							-				-							29.7
	62.5;	32.0;	4.3;	1.0	F*	274	48.2	13.1		0.7		12.0	4.0					20.0																		
24b	T22S;	R38E;	S30.	(3360')	C	334	8.6		0.6	6.3	1.8		1.5	0.6	0.9	-	2.4	1.2	0.9	1.2		0.3									-					26.3
	60.1;	28.5;	10.1;	1.2	F	88	33.0		2.3	23.9	6.8		5.7	2.3	3.4		9.1	4.5	3.4	4.5		3.4														

TABLE 4: ATRIPLEX CONFERTIFOLIA (SHADSCALE) (CONTINUED)

25	T22S; R38E; S29. (3360')	C	307	11.1		1.9	7.8	0.3		1.9	-		-	1.3		1.0		-											25.3
	60.8; 29.6; 9.2; 0	F	78	43.6		7.7	30.8	1.3		7.7				5.1		3.9													
35	T21S; R38E; S22. (5040')	C	240	12.5			0.8	6.7		0.4	5.0	2.1	-	0.4		5.4			1.3						0.4				35.0
	39.6; 26.5; 30.8; 3.0	F	84	35.7			2.4	19.0		1.2	14.2	5.9	1.2	1.2		15.5			3.5										
36	T21S; R38E; S23. (4950')	C	299	15.7			1.3	-		-	0.3	2.7	-			2.7	0.3	-	0.7	0.7			0.3						22.0
	38.2; 22.8; 36.5; 2.4	F*	288	44.7			5.6	0.7				31.2	1.0			7.9	1.7		1.7										
55	T21S; R39E; S31. (4500')	C	205	14.6		0.5	1.5	4.4	1.0	1.0	1.0	-	-			3.4	-	2.4			-								29.8
	15.7; 30.9; 49.0; 4.4	F*	346	34.4			11.0	5.8	1.4	4.9	7.5	3.2	1.7			6.9	6.1	7.5			7.8								
76	T22S; R39E; S7. (4180')	C	263	4.9	0.4	1.5	3.0	1.5	0.4	1.9				0.8		0.4	1.1												15.9
	41.2; 29.8; 29.0; 0	F*	218	54.1	15.6		6.9	3.2		0.5				9.2		2.8	6.0												
Average Substrate	53.0; 28.1; 17.6; 1.3	Average Cover		11.2	3.2	1.1	4.4	1.5	0.7	1.4	0.8	0.7	0.4	0.6	0.7	1.6	0.3	0.3	0.2	0.1								0.3	27.0
	SHADSCALE-BUD SAGEBRUSH ASSOCIATION																												
3	T21S; R37E; S35. (3400')	C	243	2.9	17.3	13.2	0.8							1.2	0.4	-													35.8
	73.8; 24.5; 1.7; 0	F	87	8.7	48.3	36.8	2.3							3.4	1.2														
4	T21S; R37E; S35. (3300')	C	272	12.1	19.1	-				0.4																	1.8		33.4
	63.8; 33.2; 3.0; 0	F	91	36.3	57.1					1.1																	5.5		
5	T21S; R37E; S36. (3380')	C	241	12.0	26.0	0.4	0.4			-																			38.9
	70.5; 29.5; 0; 0	F	94	30.9	67.0	1.1	1.1																						
15	T22S; R37E; S36. (3400')	C	237	13.1	20.2	2.9			2.1	0.8			-		0.4									-					39.5
	85.7; 13.4; 0.9; 0	F	94	32.9	51.1	7.5			5.3	2.1					1.1														
17	T22S; R37E; S12. (3350')	C	249	5.2	24.9	3.6																							33.7
	74.1; 25.9; 0; 0	F	85	15.3	72.9	10.6																							
20	T22S; R37E; S13. (3330')	C	267	10.1	19.1	2.2				0.8			-									0.4							32.6
	70.2; 26.0; 3.8; 0	F	87	31.0	58.6	6.9				2.3												1.2							
Average Substrate	73.0; 25.4; 1.6; 0	Average Cover		9.2	21.1	3.7	0.2		0.4	0.3				0.2	0.1							0.1					0.3		35.6
	BUD SAGEBRUSH ASSOCIATION																												
54	T21S; R39E; S19. (4840')	C	244		13.1		0.4	2.5	7.8	0.8	0.8	0.4		0.4		2.9	0.4	0.4								0.4			31.1
	29.8; 19.7; 43.7; 6.7	F	76		42.1		1.3	7.9	25.0	2.6	2.6	1.3		1.3		9.2	1.3	1.3								1.2			
39	T21S; R39E; S19. (4840')	C	203		15.7						1.0	1.0															2.5	0.5	20.7
	8.6; 22.3; 69.0; 0	F*	333		67.9						3.9	16.5															3.9	9.9	

from Shadscale-dominated to Shadscale-Mixed associations can be rather abrupt as evidenced by comparing Samples 6 and 7, which were taken within 50 feet of one another. Sample 6 was taken on the sandy basin floor in an area clearly dominated by shadscale with a total percent cover of 24.6 percent of which 15.6 percent was contributed by shadscale, which had a 63.5 percent absolute frequency (note amount of dead material present). A total of 9 associates were present, nine with over 1 percent cover. Sample 7, on the other hand, was from an adjacent rise averaging ca 0.6 to 1 m higher in elevation. Vegetation here had a substantially increased total cover of 34 percent, of which shadscale represents 11.3 percent with a 33.3 percent absolute frequency. It occurred with 11 associated species, 7 with over 1 percent cover.

Samples 26 and 25 illustrate a similar shift over a small distance, with only minor differences in soils.

Because of the amount of mixing of these shadscale and shadscale-mixed associations in the center of Rose Valley, they were not mapped except for an area north of Red Hill, where shadscale continues onto a sand-covered basaltic pediment.

Also, shadscale is not restricted to the areas mapped as shadscale but continues into the bajadas east of Rose Valley (see Samples 12, 13 under Ambrosia dumosa, Table 7) sometimes in high frequencies. It also occurs scattered infrequently in Mixed Desert Scrub.

3) Shadscale-Bud Sagebrush Association: Artemisia spinescens (bud sagebrush) is commonly associated with shadscale in Shadscale Scrub communities (Billings 1949, Cronquist et al 1972). In the CGSA it is locally dominant in often broad depressions only a few dm below the level of the surrounding plain. A total of 8 stands dominated by Artemisia spinescens were sampled, 6 in association with shadscale in Rose Valley and two in which shadscale was absent, north of Sugarloaf Mountain.

Substrate in the 6 Rose Valley stands was notably different than adjacent shadscale stands, in that small and large rocks were mostly absent. Bare ground averaged 73 percent cover, litter 25.4 percent, small rocks 1.6 percent and large rocks 0 percent. In these 6 stands total plant cover averaged 35.6 percent (range 32.6--39.5%) of which Artemisia spinescens represented an average of 21.1 percent cover (17.3--24.9%) with an average absolute frequency of 59.1 percent (48.3--72.9%). Atriplex confertifolia dropped down to an average cover of 9.2 percent (2.9--13.1%) and an absolute frequency averaging 25.8 percent (8.7--30.9%). Common associates include Atriplex polycarpa which occurred in all 6 stands sampled and Acamptopappus sphaerocephalus in 4 of 6 stands. A total of 11 species were associated with Artemisia in these stands.

Artemisia spinescens also occurred in basins without shadscale. Two such basins were sampled, one on the side of the large basin north of Cactus Peak (Sample 39) in an area surrounded by Atriplex canescens and the other in a small basin between Cactus Peak and Sugarloaf Mountain (Sample 54, Fig 3, Table 4). In sample 39, total percent cover was 20.7 percent, of which 15.7 percent was Artemisia spinescens with an absolute frequency of 67.9 percent. Only three other associates were present. In sample 54, total percent cover was much higher (31.1%) of which *Artemisia spinescens* contributed only 13.1 percent cover and 42.1 percent absolute frequency. This was due to the 10 associates, the most frequent of which was *Larrea tridentata*.

In almost all the *Artemisia spinescens*-dominated flats, total percent cover was higher (average 33.1%) than the stands dominated by *Atriplex confertifolia* (average 24.4%) and in both total cover was much higher than has been reported by Billings (1954) for Nevada but in line with that reported by Beatley (1976) for the Nevada Test Site, and by Zembal et al. (1978) for Rose Valley. The higher cover in the *Artemisia* stands is due to the closer spacing of the plants which is clearly visible. The relatively high cover in the shadscale stands is probably due to a combination of the non-saline nature of the habitat and possibly the recent seasons of higher precipitation during the past year, a factor noted by Beatley (1976) to increase total percent cover in shadscale on the Nevada Test Site.

Perennial and Annual Herbs: As Shadscale Scrub occurs mostly on sandy substrates at moderate elevations, perennial and particularly annual herbs are relatively well represented. The perennial species include 2 grasses (*Oryzopsis hymenoides* and *Stipa speciosa*) and two herbs (*Sphaeralcea ambigua* and *Astragalus lentiginosus*) that were listed in Table 3. In addition to these the prostrate *Euphorbia albomarginata* was common, while *Eriogonum inflatum*, *Oenothera primiveris*, and *Stillingia paucidentata* were much less frequent. Numerous annuals of the following genera occur in association with Shadscale Scrub:

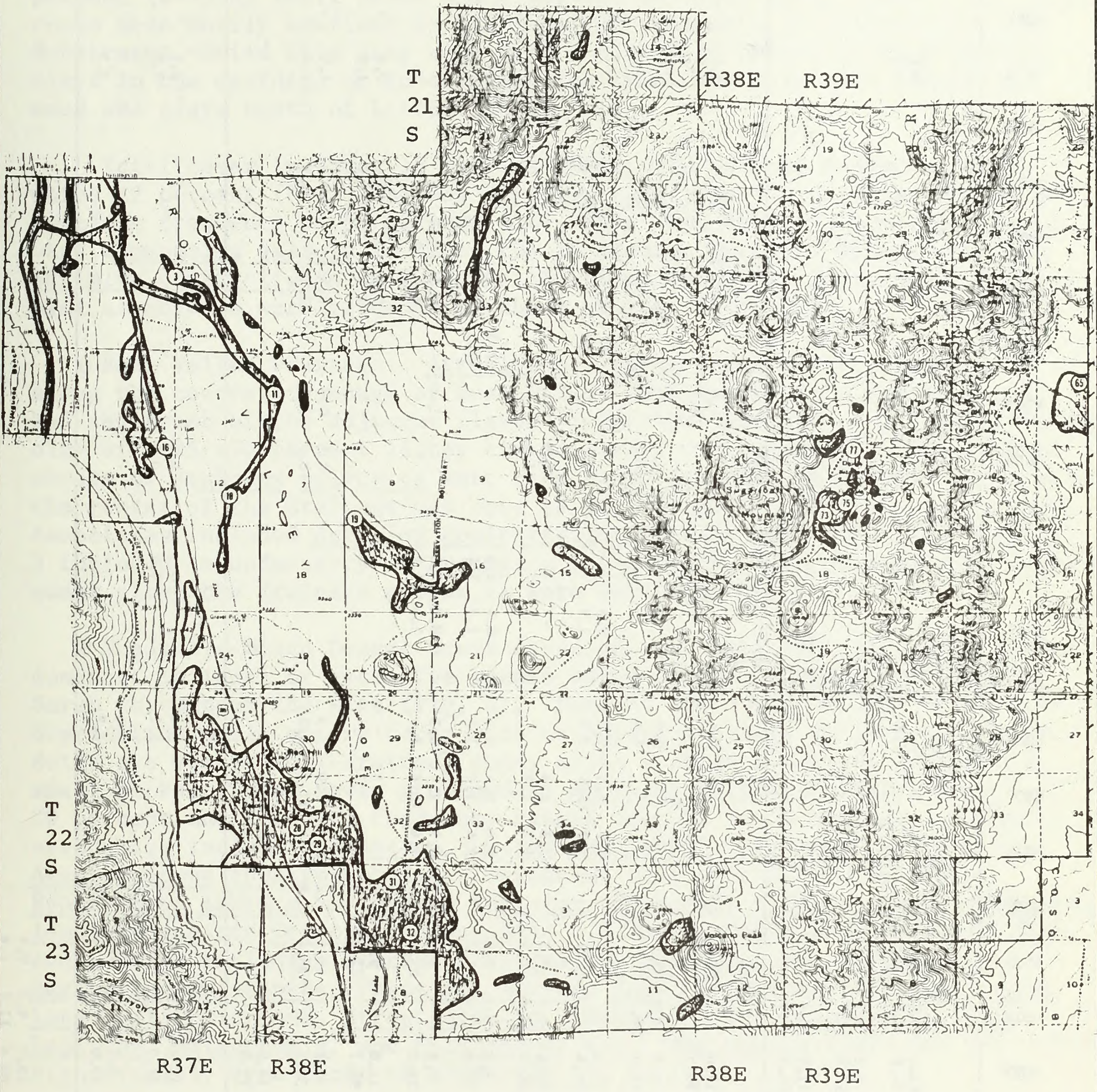
Abronia
Amsinckia
Baileya
Bromus
Camissonia
Chaenactis
Chorizanthe
Coreopsis
Cryptantha
Cuscuta
Descurainia
Dithyraea
Eremalche
Eriastrum
Eriophyllum
Erodium
Eschscholzia
Gilia
Glyptopleura
Langloisia
Lepidium
Lessingia
Linanthus
Lupinus
Malacothrix
Mentzelia
Monardella
Monoptilon
Nama
Oxytheca
Pectocarya
Phacelia
Salsola
Schismus
Streptanthella
Stephanomeria
Syntricopappus
Thelopodium
etc.

These same genera occur in sandy habitats at lower elevations throughout most of the CGSA.

ATRIPLEX POLYCARPA: *Atriplex polycarpa* (allscale or cattle spinach) becomes locally dominant in several different habitats in the CGSA, including: 1) sandy arroyos where it occurs commonly with *Hymenoclea salsola*; 2) in sandy to clay sinks and along drainages (e.g., Rose Valley); 3: in Shadscale Scrub where it can be frequent or locally abundant, completely excluding shadscale; 4) on open basaltic pediments with sandy, wind-blown soils as in the area south of Red Hill; 5) on relatively recent lava flows where it can be locally abundant; and 6) along roadsides and in other disturbed areas (e.g. along the aqueduct) where it develops as a pioneer.

The only habitat allscale seems to be excluded from is the rocky slopes containing Mixed Desert Scrub at higher elevations.

Atriplex polycarpa is a dominant shrub over about 16.8 km^2 (6.5 mi^2) which is about 5.7 percent of the CGSA (Figs. 1, 4). A total of 15 stands



EXPLANATION

Distribution of *Atriplex polycarpa* (allscale) in the CGSA. Sample sites are indicated by numbers. See Table 5 for data.

Figure 4. DISTRIBUTION OF ALLSCALE

TABLE 5: ATRIPLEX POLYCARPA (ALLSCALE).

Number	(Location) Bare Ground; Litter; Sm. Rock; (Elev.) Lg. Rock	DATA	SAMPLE	ATPO	ATCO	HYSA	GRSP	LYAN	ACSP	AMDU	ARSP	EPNE	LATR	OPEC	ORHY	EULA	DAFE	HACO	ERFA	STSP	GUMI	TESP	LEFR	DEAD	PERCENT COVER
	ROSE VALLEY DRAINAGE																								
3	T21S; R37E; S35. (3400')	C	243	13.2	2.9	0.8				0.4	17.3											1.2			35.8
	73.8; 24.5; 1.7; 0	F	87	36.8	8.0	2.3				1.2	48.3											3.4			
11	T22S; R38E; S6. (3360')	C	208	8.6	6.7						0.5													0.5	16.3
	73.7; 26.7; 0; 0	F	34	52.9	41.2						2.9													2.9	
18	T22S; R37E; S12. (3320')	C	247	12.9	2.4	0.4					1.6										0.4			1.6	19.3
	67.4; 32.5; 0; 0	F	48	66.6	12.5	2.1					8.3										2.1			8.3	
	WITH SHADSCALE MIXED DESERT SCRUB																								
1	T21S; R37E; S25. (3440')	C	251	12.0		12.0	2.4			0.4	2.4		1.2			1.6						2.4			34.4
	66.7; 17.7; 15.6 0	F	86	34.9		34.9	7.0			1.2	7.0		3.5			4.7						7.0			
19	T22S; R38E; S8. (3380')	C	255	8.2	4.7	3.5		-		0.8					0.4										17.6
	68.7; 25.7; 5.6; 0	F	45	46.7	26.7					4.4					2.2										
65	T22S; R39E; S3. (3600')	C	273	15.5		6.2		0.7	5.5	0.7		0.4					-								30.4
	53.4; 38.7; 6.2; 1.9	F*	179	44.6		19.6		3.9	20.6	3.4		3.9					3.9								
75	T22S; R39E; S7. (4350')	C	301	20.6	0.7	0.3	-	0.3	0.3	-		-		-	1.0	-								2.3	25.5
	60.9; 31.3; 7.8; 0	F	77	80.5	2.6	1.3		1.3	1.3						3.9									9.1	
73	T22S; R39E; S7. (4240')	C	259	8.5	0.8	8.1		0.8	0.4	0.4		0.4	0.8				2.3								22.4
	46.8; 18.5; 34.7; 0	F	58	37.0	3.4	36.2		3.4	1.7	1.7		1.7	3.4				10.3								
77	T22S; R39E; S7. (4520')	C	291	7.2		5.5	0.3	0.3	2.7	0.3		0.3	7.6					0.3	0.3						25.1
	54.0; 27.0; 18.9; 0	F	74	28.3		23.0	1.4	1.4	10.8	1.4		1.4	29.7					1.4	1.4						
24a	T22S; R37E; S25. (3360')	C	250	12.8		5.2		-	1.6	-								0.4		0.4		0.4	-		20.4
	74.1; 18.1; 7.8; 0	F	52	61.5		25.0			7.7									1.9		1.9		1.9			
28	T22S; R38E; S31. (3300')	C	369	7.6		6.5	2.2	0.3	3.0	1.3					0.5	0.8		0.5		0.3		1.6	-		24.6
	56.9; 22.8; 18.2; 2.2	F	91	30.8		26.4	8.8	1.1	12.1	5.5					2.2	3.3		2.2		1.1		6.6			
29	T22S; R38E; S31. (3360')	C	308	14.3			0.3	0.3																	14.9
	50.3; 18.9; 27.8; 2.9	F	46	95.6			2.2	2.2																	
	BASALTIC PEDIMENTS																								
31	T23S; R38E; S5. (3370')	C	431	12.5	9.8					1.4			0.2		0.2							2.1			26.2
	50.5; 22.5; 14.2; 12.1	F	115	47.8	36.5					5.2			0.9		0.9							7.8			
32	T23S; R38E; S5. (3700')	C	352	9.7		1.4		-		0.9					-							0.3			12.3
	38.0; 13.8; 36.6; 11.7	F	43	79.0		11.6		-		6.9												2.3			
	DISTURBED ROADSIDES																								
16	T22S; R37E; S11. (3880')	C	254	19.7	4.3	0.4																			24.4
	69.1; 30.9; 0; 0	F	62	80.6	17.7	1.6																			
	Average Substrate 60.0; 25.0; 13.0; 2.0	Cover		12.2	2.1	3.4	0.3	0.2	0.1	0.4	1.4	0.1	0.6		0.1	0.2	0.2	0.1		0.1		0.5		0.3	23.3

were quantitatively sampled (Fig. 4; Table 5) representing areas associated with the Rose Valley drainage, shadscale and Mixed Desert Scrub, basaltic pediments and disturbed roadsides. On these 15 stations substratum averaged 60 percent (range 38--74%) bare ground, 25 percent (14--39%) litter, 13 percent (0--37%) small rocks and 2 percent (0--12%) large rocks. The large rocks were mostly confined to the basaltic pediments of stations 31--32. Substrates varied from deep sand with a clay-silt matrix to hard surface clays in the drainage of Rose Valley and basalt overlain with wind-blown sand and clays north of Little Lake.

Total cover in these 15 samples averaged 23 percent (range 12--36%) of which 12 percent (7--20.5%) was *Atriplex polycarpa* representing an average absolute frequency of 55 percent (28--96%). The most frequent associates were *Hymenoclea salsola* in 12 of the 15 stands, *Ambrosia dumosa* in 9 and *Atriplex confertifolia* in 8 of the 15 stands sampled. A total of 19 perennial associates were recorded in these stands (Table 5).

1) Rose Valley Drainage: *Atriplex polycarpa* forms a continuous gallery along the central drainage of Rose Valley supplanting the shadscale and bud sagebrush of the adjacent flats. Substrate consists of a fine textured clay with 25--30 percent litter and no small or large rocks. The rounded shrubs of *Atriplex polycarpa* were very dense in some areas but in many areas the center of the drainage was open as was the case along the open playas. Associates included *Atriplex confertifolia* in samples 11 and 18 ,but sample 3 included an understory of *Artemisia spinescens*. Annuals were very infrequent along the drainage proper, as were perennial herbs.

2) Shadscale-Mixed Desert Scrub Associations: *Atriplex polycarpa* becomes dominant in local or extensive stands among shadscale and Mixed Desert Scrub throughout the site (Fig. 4). Some of these stands are in moderate depressions while others occur with no apparent change in soil conditions. Soils are mostly well-drained, sandy often with an overlying pavement of small rocks. Total cover provided by *Atriplex polycarpa* ranges from 7 to 20 percent and absolute frequency ranges from 28 to 96 percent. Frequent associates include *Hymenoclea*, *Lycium andersonii*, *Ambrosia dumosa* and *Acamptopappus sphaerocephalus*. Perennial herb associates include *Sphaeralcea ambigua*, *Eriogonum inflatum*, *Euphorbia albomarginata*, *Astragalus lentiginosus* and *Oryzopsis hymenoides*. Numerous annuals occurred on these sandy flats including species of *Eschscholzia*, *Coreopsis*, *Mentzelia*, *Amsinckia*, *Cryptantha*, *Phacelia*, *Salvia*, *Erodium*, *Bromus*, *Schismus*, *Nama*, *Langloisia*, Eriogonum, *Streptanthella*, *Linanthus*, *Descurainia*, *Lupinus*, *Lepidium*, *Malacothrix*, and *Pectocarya*, etc. The annual flora did not differ significantly from those of shadscale.

3) Basaltic pediments: At the south end of Rose Valley north of Little Lake, *Atriplex polycarpa* continues as a dominant on old basaltic pediments on sandy to clay soils that have filled in cracks in the basalt flats. The two samples made here (Samples 31, 32) show a higher frequency of small and large rocks in the substratum and a percent cover averaging 11 percent for *Atriplex polycarpa*. The northern sample showed some overflow of *Atriplex confertifolia* from the adjacent flats which was not on the other sample. Other associates with allscale include scattered *Tetradymia spinosa* on the flats, *Hymenoclea salsola* and *Oryzopsis hymenoides* in drainages, and *Ambrosia dumosa* and *Lycium andersonii* on rocky hills and outcroppings. The understory

was covered with a dense population Bromus rubens which occurred with species of Salvia, Nama, Eriastrum, and Eriogonum. Common perennial herbs include Eriogonum inflatum, Euphorbia albomarginata and Sphaeralcea ambigua.

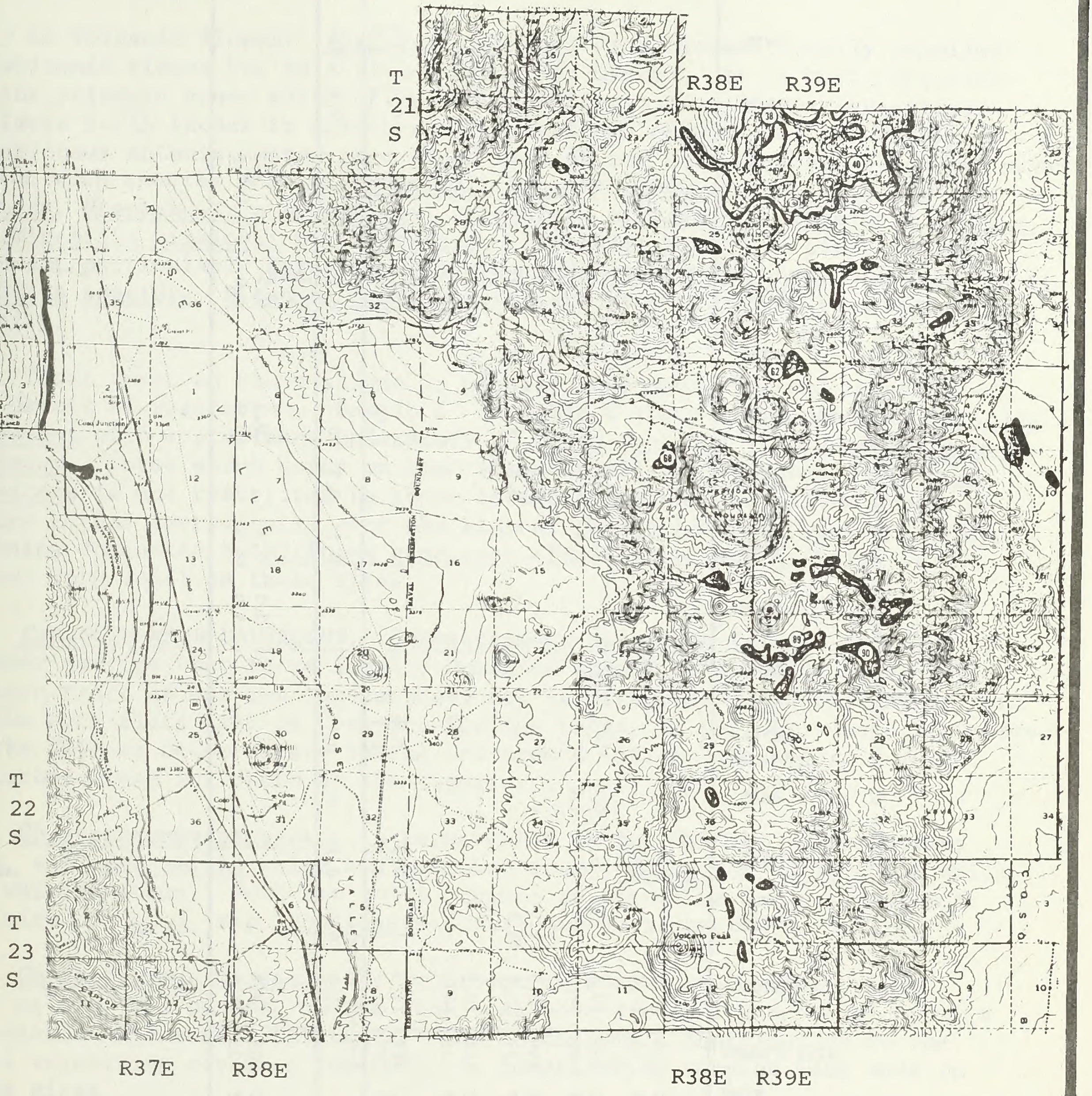
4) Disturbed Areas: Allscale is a pioneer in disturbed habitats throughout most of the area below 4400 feet elevation where it borders roads and trails. It also occurs on the fill over the two aqueduct right-of-ways. Only one sample (16) was made in these sites, along the shoulder of Highway 395 south of Coso Junction where Atriplex polycarpa had 19.7 percent cover and an absolute frequency of 80.6 percent. The only associates here were Atriplex confertifolia and Hymenoclea salsola, both coming from the adjacent shadscale-dominated fields. Atriplex polycarpa is common along most trails and roads on the site, whether paved or not. These narrow strips of allscale, however, were not mapped. Over the aqueduct fill, Atriplex polycarpa occurs in open stands with Hymenoclea salsola, Larrea tridentata, Ambrosia dumosa, Lepidium fremontii, Stephanomeria pauciflora as well as Chrysothamnus nauseosus ssp. hololeucus and ssp. consimilis.

Allscale is also frequent along sandy arroyos mixed with Hymenoclea salsola, and a few other shrubs. It forms very dense stands in some arroyo areas as along the road to the pumice mines north of the junction with the road to the Naval Weapons Center. In this area it blends in with Ambrosia dumosa-Larrea tridentata-dominated scrub to the north.

As can be seen from the above discussion, the distribution and associations of Atriplex polycarpa are by no means uniform over the site.

ATRIPLEX CANESCENS: Atriplex canescens (four-winged saltbush) has a rather restrictive distribution over the CGSA, becoming dominant only in small or large basins in the eastern half of the CGSA (Figs. 1, 5). Atriplex canescens is a dominant shrub over about 7.2 km^2 (2.8 mi^2) or ca. 2.5 percent of the CGSA. A total of 6 stands were sampled (Table 6), consisting of two contrasting habitat types: 1) in depressions and 2) on volcanic slopes.

1) Depressions: Atriplex canescens is often locally dominant, forming rather open stands in water or cold-air depressions with sandy (sample 40) or more often clayish-sandy soils overlain by small rocks. The five stands sampled in the flats had substrates consisting of 49 percent (31.7--81.6%) bare ground, 23 percent (16--29.8%) litter, 27 percent (2.4--45.9%) small rocks and 0.6 percent large rocks. Total cover averaged 15 percent (range 10.6--19.6%) of which 13 percent (5.5--18%) was Atriplex canescens. In all but 1 sample, which was mixed with winter fat (Eurotia) and some perennial herbs, Atriplex canescens was truly dominant, representing over 92 percent (range 52.4--100%) of the cover. Associates were not consistent from stand to stand. They were mostly species of Mixed Desert Scrub (Grayia, Hymenoclea, Eurotia, Tetradymia) into which Atriplex canescens always intergraded. Only 14 perennial species were recorded in association with Atriplex canescens. The samples studied had from 1 to 5 associated perennial species. Most of these were perennial grasses and herbs as Stipa speciosa, Oryzopsis hymenoides, Sitanion hystrix, Sphaeralcea ambigua, and Astragalus lentiginosus (Table 6). In the eastern margins of the flats north of Cactus Peak, Atriplex canescens intergrades strongly with Mixed Desert Scrub and contains an overlying stand of Joshua Trees (Fig. 1) near the western base of the adjacent mountain.



EXPLANATION

Distribution of Atriplex canescens (four-winged saltbush), shaded areas, and Chrysothamnus nauseosus (rabbit bush), solid, in the CGSA. Sample sites are indicated for Atriplex canescens by numbers. See Table 6 for data.

Figure 5. DISTRIBUTION OF FOUR-WINGED SALTBUSH AND RABBIT BUSH

TABLE 6: ATRIPLEX CANESCENS (FOUR-WINGED SALTBUSH).

Number	Location (Elev.) Bare Gr.; Litter; Sm. Rock; Lg. Rock	DATA	SAMPLE SIZE	ATCA	EULA	HYSA	GRSP	TESP	GUMI	MIBI	STSP	ORHY	SIHY	STePA	SPAM	ASLE	ERIN	ATPO	LYAN	DAFE	PERCENT COVER
	IN DEPRESSIONS																				
89	T22S; R39E; S19. (4120')	C	244	18.0		0.4															18.4
	37.1; 23.2; 39.7; 0	F	45	97.8		2.2															
40	T21S; R39E; S19-20. (4950')	C	252	13.5		-	0.4	-	-		0.4	-									14.3
	81.6; 16.0; 2.4; 0	F	36	94.4			2.8				2.8										
38	T21S; R39E; S19. (4900')	C	199	5.5	2.5							0.5	1.0		1.0						10.6
	35.3; 29.8; 34.8; 0	F	21	52.4	23.8							4.8	9.5		9.5						
68	T22S; R38E; S11. (4100')	C	246	10.6								-		-		-					10.6
	31.7; 22.4; 45.9; 0	F	26	100																	
90	T22S; R39E; S20. (4000')	C	396	17.9		0.3		0.3										0.5	0.3	0.3	19.6
	61.5; 22.1; 13.5; 2.8	F	77	92.2		1.3		1.3										2.6	1.3	1.3	
Average substrate		Average cover																			
	49.4; 22.7; 27.3; 5.6			11.1	0.5	0.1	0.1	0.1			0.1	0.1	0.2		0.2			0.1	0.1	0.1	14.7
	VOLCANIC SLOPES																				
62	T22S; R39E; S6. (4400')	C	205	7.8						0.5	5.4		0.5		0.5		1.5				16.1
	1.0; 35.5; 18.2; 45.3	F	33	48.5						3.0	33.3		3.0		3.0		9.1				

This stand is the largest *Atriplex canescens*-dominated stand on the site. *Atriplex canescens* continues with reduced cover across the nearly barren flats in the basin floor.

2) Volcanic Slopes: *Atriplex canescens* also becomes locally prominent on volcanic slopes but in a rather irregular manner. It is most noticeable on the volcanic cones north of Sugarloaf Mountain among large lava-cinder boulders 5--15 inches in diameter where it forms often local and highly conspicuous colonies, often in a broad band at the base of these slopes in association with species such as *Tetradymia spinosa*, *Hymenoclea salsola*, *Grayia spinosa*, *Stephanomeria pauciflora*, *Brickellia microphylla*, *Petalonyx nitidus*, and *Mirabilis bigelovii* var. *retrorsa*. Perennial herbs are often locally abundant, particularly *Eriogonum inflatum*, *Sphaeralcea ambigua*; and grasses such as *Stipa speciosa*, *Sitanion hystrix* often are very prominent to dominant locally.

Total cover on these slopes is usually only moderate, and large areas are devoid of vegetation. Sample 62 on Table 6 shows a dominance of *Atriplex canescens* with a prominent understory of *Stipa speciosa* with some *Eriogonum inflatum*. Total shrub cover on that site was only 8.3 percent. *Atriplex canescens* is not restricted to these irregular patches on cinder cones but occurs rather sporadically over the slopes. These habitats were not mapped as being dominated by *Atriplex canescens* (Figs. 1, 5) for *Atriplex* is often very local on these sites.

CHRYSOTHAMNUS NAUSEOSUS: *Chrysothamnus nauseosus* (rabbit brush) is a pioneer species that forms locally dominant stands in the CGSA along the eastern tract of the Los Angeles aqueduct, in disturbed areas near Sykes, and in the open flats east of Coso Hot Springs (Figs. 1, 5). It occurs elsewhere in the CGSA, as below Haiwee Spring and around Little Lake, and in some disturbed areas not shown in the figures.

Chrysothamnus nauseosus is represented on the CGSA by 3 subspecies: *C. n.* ssp. *consimilis* which has greenish stems; *C. n.* ssp. *hololeucus* which has whitish stems. Both are quite common in disturbed areas throughout the site. *C. n.* ssp. *mohavensis* occurs mainly below Haiwee Spring.

Chrysothamnus nauseosus is prominent in stands over about 0.5 km^2, (0.2 mi^2) or 0.2 percent of the CGSA. At most stands its presence appears associated with past disturbance. Due to the small contribution to the total vegetative cover on the CGSA, no quantitative samples were made in these sites.

In the aqueduct west of Highway 395, both *Chrysothamnus n.* ssp. *consimilis* and ssp. *hololeucus* are present as large round shrubs 3--4 ft high in the disturbed fill area over the pipelines. Mixed with the above are a scattering of shrubs such as *Hymenoclea salsola*, *Haplopappus cooperi*, *Larrea tridentata*, *Ambrosia dumosa*, *Lepidium fremontii*, *Stephanomeria pauciflora* and occasionally *Chrysothamnus teretifolius*. Common annuals include *Bromus rubens*, *Bromus tectorum*, *Erodium cicutarium* and species of *Camissonia* and *Amsinckia*. In other areas, *Chrysothamnus* is mixed with many of the same associates in similar disturbed habitats.

AMBROSIA DUMOSA (BURRO WEED): This is dominant as an understory component over about 96.3 km^2 (37.2 mi^2) or 32.8 percent of the total surface of the

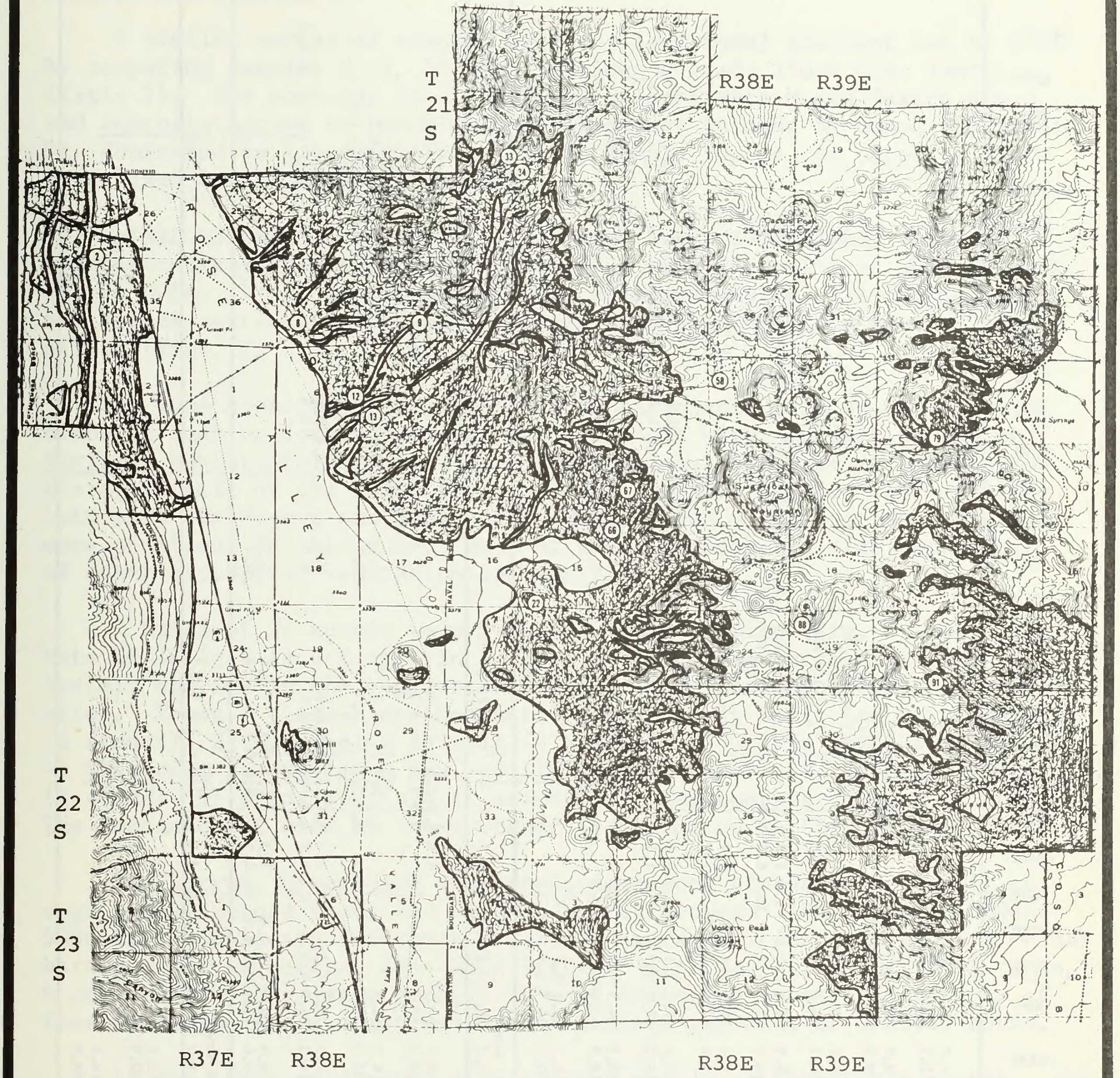
CGSA mainly on coarse sandy soils bordering Rose Valley between Shadscale Scrub in the basin and Mixed Desert Scrub at higher elevations (Figs. 1, 6). *Ambrosia dumosa* also occurs in the far southeastern corner of the CGSA where it extends from the low valley onto the upper south-facing slopes. Adjacent north-facing slopes in contrast have the more cold-adapted Mixed Desert Scrub. Other stands of *Ambrosia dumosa* occur near Coso Hot Springs mostly on southerly-facing slopes and in the extreme southwest corner of the CGSA (Figs. 1, 6). In practically all these areas, *Ambrosia dumosa* is associated with an overstory of creosote bush (*Larrea tridentata*) which also continues over portions of Mixed Desert Scrub, *Atriplex confertifolia*, etc.

Data in Table 7 is separated into 2 classes: 1) areas on sandy or pebbly substrate on plains and low slopes (8 samples) and 2) areas on rocky slopes (4 samples). A third class consists of areas in which *Larrea* occurs exclusive of any understory component, this will be discussed with *Larrea*.

1) *Ambrosia dumosa* understory of sandy plains and slopes (8 stands). In these 8 stands, substrate consisted of an average of 56 percent bare ground, 19 percent litter, 21 percent small rocks and 5 percent large rocks. Total cover averaged 24 percent (range 18.1--34.4%). Total cover is highest in stands 2 and 6 where *Larrea* is large and shows a higher percent cover than *Ambrosia dumosa*. In the other 6 stands, cover of *Larrea* is less than that of *Ambrosia dumosa*, and plants of *Larrea* were smaller. In the 8 stands, the average and range of cover for *Larrea* was 9 (2.4--25.9) percent and *Ambrosia* was 8.3 (4.5--12.1) percent. Prominent associates include *Acamptopappus* 1.5 (0--5.4) percent, *Hymenoclea salsola* 0.9 (0--2.4) percent, *Atriplex confertifolia* 1.8 (0--8.3) percent and *Dalea fremontii* 0.6 (0--1.9) percent. Other common associates include *Lycium andersonii*, *Ephedra nevadensis*, *Atriplex polycarpa*, *Grayia speciosa*, etc. A total of 19 species were associated with *Ambrosia dumosa* on these sandy habitats.

2) On rocky slopes, the total cover averaged 30 (25.8--39.8) percent. *Larrea* was mostly smaller in stature and its total contribution to cover was reduced 6.6 (4.7--8.7) percent, usually below that of the more common *Ambrosia dumosa* 11.4 (5.2--16) percent. On these rocky slopes other subdominants were more consistently present, including *Eriogonum fasciculatum* ssp. *polifolium*,which had an average and range of cover of 1.8 (0.3--3.4) percent for the 4 stands and *Stipa speciosa* with a cover of 1.6 (0--6.0) percent. Other common associates included *Lycium andersonii* 1.8 (0--4) percent and *Hymenoclea salsola* 1.4 (0--4.6) percent. *Machaeranthera tortifolia*, *Mirabilis bigelovii*, *Salazaria mexicana*, *Stephanomeria pauciflora* and other species that also continued into Mixed Desert Scrub were also common associates. A total of 21 species are associated with *Ambrosia dumosa* on these rocky slopes.

A direct comparison of plains vs. rocky habitats is offered by ample 66 on sandy plains and Sample 67 on adjacent rocky slopes. On the sandy plain (Sample 66) *Larrea* was comparatively tall (14.2 dm) and was common,with an absolute frequency of 28.5 percent and a cover of 20.3 percent as compared to the frequency (42.0 percent) and cover (4.5 percent) of *Ambrosia dumosa*. Common associates here included *Acamptopappus*, *Dalea fremontii*, and *Hymenoclea salsola*. On the rocky adjacent slopes (Sample 67) *Larrea* was much smaller in size with an average height of 8.7 dm and it has a frequency of 25.6 percent and cover of 8.7 percent while that of *Ambrosia*



EXPLANATION

Distribution of *Ambrosia dumosa* (burro weed) in the CGSA. Sample sites are indicated by numbers. See Table 7 for data.

Figure 6. DISTRIBUTION OF BURRO WEED

TABLE 7: AMBROSIA DUMOSA (BURRO WEED); LARREA TRIDENTATA (CREOSOTE BUSH)

Number	Location (Elev.) Bare Gr.; Litter; Sm. Rock; Lg. Rock	DATA	SAMPLE SIZE	LATR	AMDU	HYSA	GRSP	ACSP	DAFE	LYAN	ERFApo	TESP	MATO	EPNE	ATPO	ATCO	STSP	ORHY	EULA	HACO	MIBI	OPEC	OPBA	ECPO	STePA	YUBE	SAME	CHTE	GUMI	ARSP	ENVIac	ERIN	PERCENT COVER
	Plains																																
2	T21S; R37E; S34. (3560')	C	247	25.9	6.5	-	-	1.2		0.8		-			-																		34.4
	64.3; 32.4; 2.9; 0.4	F	85	75.3	18.8			3.5		2.3																							
8	T21S; R38E; S31. (3430')	C	248	3.6	8.5	2.0	2.8			0.4		0.4		0.4			-	-			-												18.1
	46.2; 12.9; 40.5; 0.4	F	45	20.0	46.7	11.1	15.6			2.2		2.2		2.2																			
9	T21S; R38E; S32. (3720')	C	258	5.0	9.3	-	-		1.9	-		-		0.4	2.7	1.5							-		-								20.8
	25.5; 7.2; 58.5; 8.7	F	45	24.1	44.4				9.2					1.9	13.0	7.4																	
34	T21S; R38E; S21. (4320')	C	276	6.9	5.4	0.7	-	5.4	1.8	1.1				0.4	2.9	2.5	-	-	0.4		-	-				0.4							27.9
	70.7; 19.3; 7.8; 2.2	F	77	24.7	19.4	2.6		19.4	6.5	3.8				1.3	10.4	9.1			1.3							1.3							
12	T22S; R38E; S5-6. (3600')	C	458	1.5	12.2	1.1	0.2		0.2					-	2.0	2.2				-			0.4										19.8
	55.8; 15.3; 17.1; 11.8	F	91	7.6	61.5	5.5	1.1		1.1						9.9	11.0							2.2										
13	T22S; R38E; S5. (3600')	C	372	2.4	7.5	2.4		0.3	0.3	0.3		-		0.3	0.8	8.3					0.3		-	0.3						0.3			23.5
	43.9; 20.6; 23.9; 11.5	F	87	10.3	32.2	10.3		1.2	1.2	1.2				1.2	3.4	35.6					1.2			1.2						1.2			
66	T22S; R38E; S15. (3500')	C	266	20.3	4.5	0.7	-	3.0	0.7	-							-	-	-	-	-												29.2
	65.0; 20.0; 13.2; 1.1	F*	119	28.5	42.0	0.8	3.3	15.1									1.7	2.5	0.8	4.2	8.4												
22	T22S; R38E; S22. (3520')	C	206	6.7	12.1	0.2	0.7	1.7		-								-	-			-								0.7			22.1
	74.9; 20.8; 4.1; 0	F	102	30.4	54.9	1.0	2.9	7.8																						2.9			
	Average Substrate 55.8; 18.6; 20.5; 4.5	Average cover		9.0	8.2	0.9	0.4	1.4	0.2	0.3			0.2	1.0	1.8															0.1			24.5
	Rocky Slopes																																
67	T22S; R38E; S11. (3600')	C	271	8.7	10.5	-			0.4	2.1	2.5		0.4				-				-		-	-	0.4								25.8
	21.2; 15.4; 30.0; 33.3	F*	172	25.6	70.3					0.6	1.2		1.2										0.6	0.6									
33	T21S; R38E; S21. (4400')	C	298	4.7	13.7		-			4.0	3.4		0.7	-			6.0			0.7	0.3			0.3	2.0		2.7	1.0	0.3				39.8
	10.7; 19.4; 20.4; 49.5	F	120	11.7	34.2					10.0	8.3		1.7				15.0			1.7	0.8			0.8	5.0		6.7	2.5	0.8				
79	T22S; R39E; S5. (4200')	C	231	7.3	5.2	1.3		1.7	2.2	0.9	1.2	0.4	0.9				0.4			0.4	0.9		-		0.4		0.4				-	2.2	25.8
	36.4; 21.5; 9.2; 32.9	F*	210	14.3	29.0	4.3		4.8	6.7	1.0	7.2		2.4				1.9				1.4						2.4				0.5	23.3	
91	T22S; R39E; S20. (4040')	C	367	6.0	16.0	4.6	0.6		1.3		0.3	0.3		0.6			0.3							-									30.0
	16.7 25.1; 4.1; 54.1	F	110	20.0	53.6	15.5	1.8		4.5		0.9	0.9		1.8			0.9																
	Average Substrate 21.2; 20.3; 15.9; 42.4	Average cover		6.7	11.3	1.5	0.1	0.4	1.0	1.7	1.9	0.2	0.5	0.1		1.7			0.3	0.3					0.7		0.8	0.2				0.6	30.3
	LATR (Exclusive)																																
88	T22S; R39E; S19. (4250')	C	297	12.1																													12.1
	51.2; 11.8; 32.9; 4.4	F	36	100.0																													
58	T22S; R38E; S1. (4200')	C	207	24.2			0.5																										24.7
	78.0; 21.5; 0.5; 0	F	51	98.0			2.0																										

dumosa which had a much higher frequency of 70.3 percent and an increased cover of 10.5 percent. Common associates included *Lycium andersonii* and *Eriogonum fasciculatum*.

A similar series of samples over an elevational gradient can be seen by comparing Samples 8, 9, 12, and 13 along a grade above Coso Junction (Table 7). The contrast in north-facing slopes with Mixed Desert Scrub and *Ambrosia*-*Larrea* on south-facing slopes can be made by comparing sample 91, dominated by *Ambrosia* (Table 7), and sample 92, on the opposite slope with Mixed Desert Scrub (Table 8).

MIXED DESERT SCRUB: The Mixed Desert Scrub is a highly variable vegetation type prominent over about 117.8 km^2 (45.5 mi^2) or 40.1 percent of the CGSA. It is mostly confined to upland areas on well-drained flats and slopes, extending into rocky ridges with some shift in species composition (Figs. 1, 7).

In some areas Mixed Desert Scrub is associated with an overstory of creosote bush or Joshua tree and it may mingle with *Ambrosia dumosa* and *Atriplex confertifolia*, etc. As noted previously, this is an association characteristic of the transition zone and contains species that continue both into the Mojave and Great Basin Deserts and other species that are more prominent in this zone. Many of these species are also components of other widespread vegetation associations.

A total of 32 stands were quantitatively sampled (Fig. 7, Table 8). Data in Table 8 is arranged in 7 classes reflecting local dominance of certain species in the vegetational mosaic that characterizes this association. These 7 classes are dominated respectively by 1) *Larrea tridentata* (6 stands); 2) *Hymenoclea salsola* (9 stands); 3) *Grayia spinosa* (8 stands); 4) *Eriogonum fasciculatum* ssp. *polifolium* (4 stands); 5) *Eurotia lanata* (1 stand); 6) *Stipa speciosa* (2 stands); 7) *Haplopappus cooperi* (1 stand). The dominance of each of these stands is indicated in Fig. 7.

The *Larrea*, *Hymenoclea* and *Grayia*-dominated stands occur mostly in open, well-drained flats and slopes, mostly between 1100--1500 m (3600--5000 ft). Substrate for these 3 classes averages 51 percent (range 17--75%) bare ground, 16 percent (12--40%) litter, 16 percent (2--51%) small rocks, 6 percent (0--33%) large rocks. In most instances substrate consists of fine to coarse sands, sometimes with a surface pavement of smaller rocks.

1) The *Larrea*-dominated stands occur mostly on the gentle slopes. The 8 stands have a total percent cover averaging 23.8 percent (range 19--31%) of which *Larrea* contributes an average of 13.5 percent (9.8--25.8%). Subdominants and their respective average and range of percent cover include *Hymenoclea salsola* 3.4 (0.5--10.5) percent, *Dalea fremontii* 16 (0--3.5) percent, *Acamptopappus sphaerocephalus* 1.2 (0--3.5) percent and *Lycium andersonii* 1.0 (0--2.2) percent. A total of 25 species occur in association with *Larrea* in these 6 sites.

2) *Hymenoclea salsola*-dominated stands again occur in mostly sandy flats and slopes. *Larrea*, when present, is infrequent. These stands are on the average, at higher elevation (4200 ft) than the *Larrea*-dominated stands (3500 ft). Average total cover is 29.8 (19--52.7) percent for the 9 stands of which *Hymenoclea* contributes an average of 11.45 (5--17.5) percent cover.

TABLE 7: AMBROSIA DUMOSA (BURRO WEED); LARREA TRIDENTATA (CREOSOTE BUSH)

Number	Location (Elev.) Bare Gr.; Litter; Sm. Rock; Lg. Rock	DATA	SAMPLE SIZE	LATR	AMDU	HYSA	GRSP	ACSP	DAFE	LYAN	ERFApo	TESP	MATO	EPNE	ATPO	ATCO	STSP	ORHY	EULA	HACO	MIBI	OPEC	OPBA	ECPO	STePA	YUBE	SAME	CHTE	GUMI	ARSP	ENVIac	ERIN	PERCENT COVER
	Plains																																
2	T21S; R37E; S34. (3560')	C	247	25.9	6.5	-	-	1.2		0.8		-			-																		34.4
	64.3; 32.4; 2.9; 0.4	F	85	75.3	18.8			3.5		2.3																							
8	T21S; R38E; S31. (3430')	C	248	3.6	8.5	2.0	2.8			0.4		0.4		0.4			-	-			-												18.1
	46.2; 12.9; 40.5; 0.4	F	45	20.0	46.7	11.1	15.6			2.2		2.2		2.2																			
9	T21S; R38E; S32. (3720')	C	258	5.0	9.3	-	-		1.9	-		-		0.4	2.7	1.5							-		-								20.8
	25.5; 7.2; 58.5; 8.7	F	45	24.1	44.4				9.2					1.9	13.0	7.4																	
34	T21S; R38E; S21. (4320')	C	276	6.9	5.4	0.7	-	5.4	1.8	1.1				0.4	2.9	2.5	-	-	0.4		-	-				0.4							27.9
	70.7; 19.3; 7.8; 2.2	F	77	24.7	19.4	2.6		19.4	6.5	3.8				1.3	10.4	9.1			1.3							1.3							
12	T22S; R38E; S5-6.(3600')	C	458	1.5	12.2	1.1	0.2		0.2					-	2.0	2.2				-			0.4										19.8
	55.8; 15.3; 17.1; 11.8	F	91	7.6	61.5	5.5	1.1		1.1						9.9	11.0							2.2										
13	T22S; R38E; S5. (3600')	C	372	2.4	7.5	2.4		0.3	0.3	0.3		-		0.3	0.8	8.3					0.3		-	0.3						0.3			23.5
	43.9; 20.6; 23.9; 11.5	F	87	10.3	32.2	10.3		1.2	1.2	1.2				1.2	3.4	35.6					1.2			1.2						1.2			
66	T22S; R38E; S15. (3500')	C	266	20.3	4.5	0.7	-	3.0	0.7	-							-	-	-	-	-												29.2
	65.0; 20.0; 13.2; 1.1	F*	119	28.5	42.0	0.8	3.3	15.1									1.7	2.5	0.8	4.2	8.4												
22	T22S; R38E; S22. (3520')	C	206	6.7	12.1	0.2	0.7	1.7		-								-	-			-								0.7			22.1
	74.9; 20.8; 4.1; 0	F	102	30.4	54.9	1.0	2.9	7.8																						2.9			
	Average Substrate 55.8; 18.6; 20.5; 4.5	Average cover		9.0	8.2	0.9	0.4	1.4	0.2	0.3			0.2	1.0	1.8															0.1			24.5
	Rocky Slopes																																
67	T22S; R38E; S11. (3600')	C	271	8.7	10.5	-			0.4	2.1	2.5		0.4				-				-		-	-	0.4								25.8
	21.2; 15.4; 30.0; 33.3	F*	172	25.6	70.3					0.6	1.2		1.2										0.6	0.6									
33	T21S; R38E; S21. (4400')	C	298	4.7	13.7		-			4.0	3.4		0.7	-			6.0			0.7	0.3			0.3	2.0		2.7	1.0	0.3				39.8
	10.7; 19.4; 20.4; 49.5	F	120	11.7	34.2					10.0	8.3		1.7				15.0			1.7	0.8			0.8	5.0		6.7	2.5	0.8				
79	T22S; R39E; S5. (4200')	C	231	7.3	5.2	1.3		1.7	2.2	0.9	1.2	0.4	0.9				0.4			0.4	0.9		-		0.4		0.4				-	2.2	25.8
	36.4; 21.5; 9.2; 32.9	F*	210	14.3	29.0	4.3		4.8	6.7	1.0	7.2		2.4				1.9				1.4						2.4				0.5	23.3	
91	T22S; R39E; S20. (4040')	C	367	6.0	16.0	4.6	0.6		1.3		0.3	0.3		0.6			0.3							-									30.0
	16.7 25.1; 4.1; 54.1	F	110	20.0	53.6	15.5	1.8		4.5		0.9	0.9		1.8			0.9																
	Average Substrate 21.2; 20.3; 15.9; 42.4	Average cover		6.7	11.3	1.5	0.1	0.4	1.0	1.7	1.9	0.2	0.5	0.1		1.7			0.3	0.3					0.7		0.8	0.2				0.6	30.3
	LATR (Exclusive)																																
88	T22S; R39E; S19. (4250')	C	297	12.1																													12.1
	51.2; 11.8; 32.9; 4.4	F	36	100.0																													
58	T22S; R38E; S1. (4200')	C	207	24.2			0.5																										24.7
	78.0; 21.5; 0.5; 0	F	51	98.0			2.0																										

dumosa which had a much higher frequency of 70.3 percent and an increased cover of 10.5 percent. Common associates included *Lycium andersonii* and *Eriogonum fasciculatum*.

A similar series of samples over an elevational gradient can be seen by comparing Samples 8, 9, 12, and 13 along a grade above Coso Junction (Table 7). The contrast in north-facing slopes with Mixed Desert Scrub and *Ambrosia-Larrea* on south-facing slopes can be made by comparing Sample 91, dominated by *Ambrosia* (Table 7), and Sample 92, on the opposite slope with Mixed Desert Scrub (Table 8).

MIXED DESERT SCRUB: The Mixed Desert Scrub is a highly variable vegetation type prominent over about 117.8 km^2 (45.5 mi^2) or 40.1 percent of the CGSA. It is mostly confined to upland areas on well-drained flats and slopes, extending into rocky ridges with some shift in species composition (Figs. 1, 7).

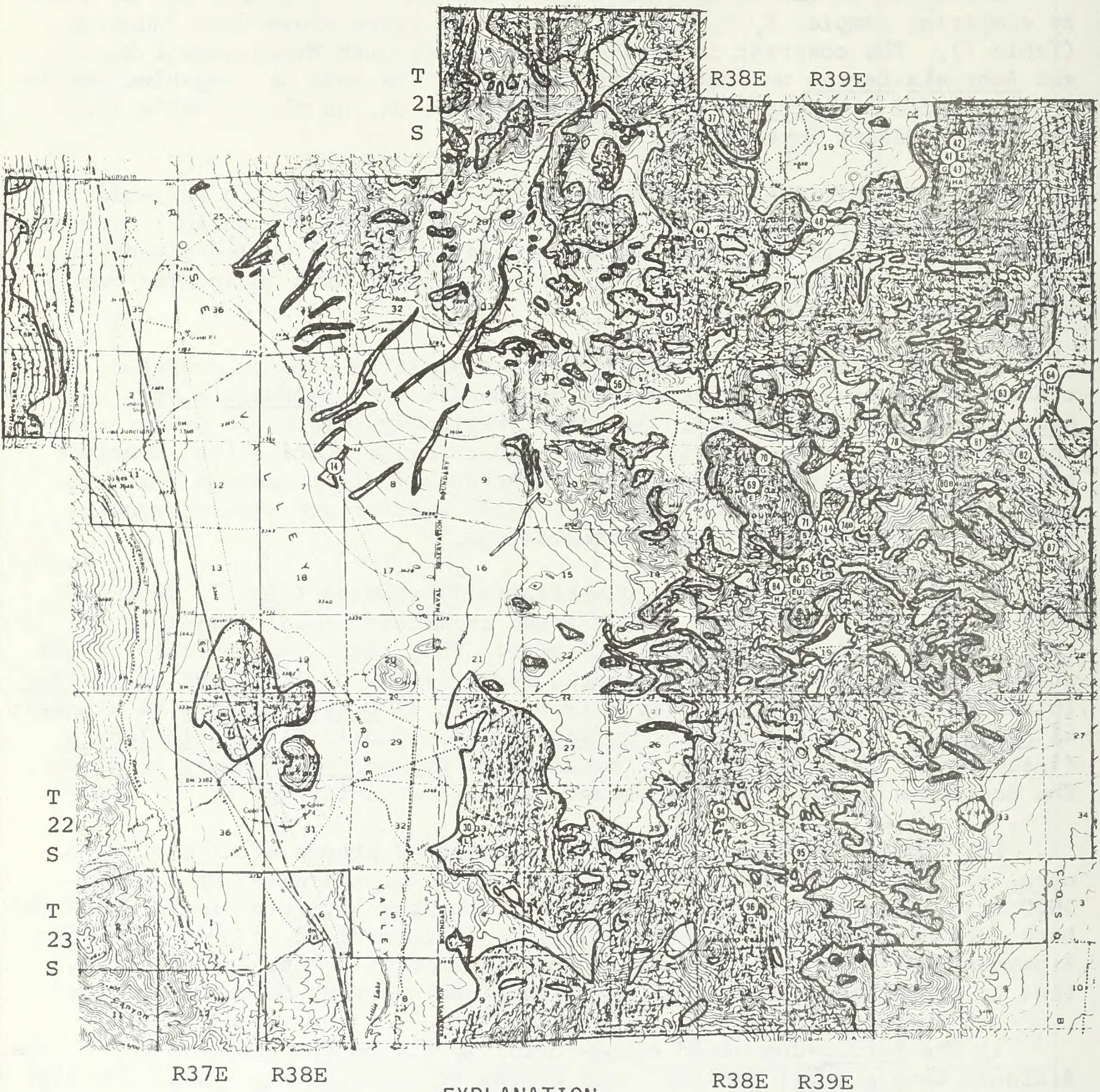
In some areas Mixed Desert Scrub is associated with an overstory of creosote bush or Joshua tree and it may mingle with *Ambrosia dumosa* and *Atriplex confertifolia*, etc. As noted previously,this is an association characteristic of the transition zone and contains species that continue both into the Mojave and Great Basin Deserts and other species that are more prominent in this zone. Many of these species are also components of other widespread vegetation associations.

A total of 32 stands were quantitatively sampled (Fig. 7, Table 8). Data in Table 8 is arranged in 7 classes reflecting local dominance of certain species in the vegetational mosaic that characterizes this association. These 7 classes are dominated respectively by 1) *Larrea tridentata* (6 stands); 2) *Hymenoclea salsola* (9 stands); 3) *Grayia spinosa* (8 stands); 4) *Eriogonum fasciculatum* ssp. *polifolium* (4 stands); 5) *Eurotia lanata* (1 stand); 6) *Stipa speciosa* (2 stands); 7) *Haplopappus cooperi* (1 stand). The dominance of each of these stands is indicated in Fig. 7.

The *Larrea*, *Hymenoclea* and *Grayia*-dominated stands occur mostly in open, well-drained flats and slopes, mostly between 1100--1500 m (3600--5000 ft). Substrate for these 3 classes averages 51percent (range 17--75%) bare ground, 16 percent (12--40%) litter, 16 percent (2--51%) small rocks, 6 percent (0--33%) large rocks. In most instances substrate consists of fine to coarse sands,sometimes with a surface pavement of smaller rocks.

1) The *Larrea*-dominated stands occur mostly on the gentle slopes. The 8 stands have a total percent cover averaging 23.8 percent (range 19--31%) of which *Larrea* contributes an average of 13.5 percent (9.8--25.8%). Subdominants and their respective average and range of percent cover include *Hymenoclea salsola* 3.4 (0.5--10.5) percent, *Dalea fremontii* 16 (0--3.5) percent, *Acamptopappus sphaerocephalus* 1.2 (0--3.5) percent and *Lycium andersonii* 1.0 (0--2.2) percent. A total of 25 species occur in association with *Larrea* in these 6 sites.

2) *Hymenoclea salsola*-dominated stands again occur in mostly sandy flats and slopes. *Larrea*, when present, is infrequent. These stands are on the average, at higher elevation (4200 ft) than the *Larrea*-dominated stands (3500 ft). Average total cover is 29.8 (19--52.7) percent for the 9 stands of which *Hymenoclea* contributes an average of 11.45 (5--17.5) percent cover.



EXPLANATION

Distribution of Mixed Desert Scrub on the CGSA. Sample sites are indicated by numbers. Dominant species for each site is indicated by the following subtending letters. (See Table 8 for data.)

L	Larrea tridentata (creosote bush)
H	Hymenoclea salsola (cheesebush)
G	Grayia spinosa (hop sage)
E	Eriogonum fasciculatum var. polifolium (California buckwheat)
EU	Eurotia lanata (winter fat)
S	Stipa speciosa (needle grass)
HA	Haplopappus cooperi (Cooper's goldenbush)

Figure 7. DISTRIBUTION OF MIXED DESERT SCRUB

TABLE 8: MIXED DESERT SCRUB

Number	Bare Ground	Litter	Sm. Rock	Lg. Rock	DATA	SAMPLE SIZE	LATR	HYSA	GRSP	ERFApo	EULA	ACSP	EPNE	LYAN	LYCO	DAFR	TESP	HACO	AMDU	SAME	YUBE	STSP	ORHY	POSC	SIHY	OPBA	OPEC	ATPO	ATCA	ATCO	ENVI	HALI	CHTE	LEFE	ARSP	PETH	MIBI	MATO	ERIN	ST•PA	GUMI	ARTR	GAMA	CHVI	DEAD	PERCENT COVER
74a	T22S;	R39E;	S7-18.	(4160')	C	256	10.9	4.3								1.6												4.3	0.4																	21.5
	46.6;	25.9;	27.5;	0	F	54	51.9	18.5								7.4												20.4	1.9																	
53	T21S;	R38E;	S36.	(4350')	C	201	13.9	0.5	0.5			1.5	1.0	-		-			0.5				1.5														-	-	-							19.4
	61.7;	32.3;	3.5;	2.5	F*	295	27.8	2.4	1.4			16.6	3.7	2.4		0.3							32.9														1.7	0.3	10.5							
78	T22S;	R39E;	S5.	(4050')	C	201	10.0	0.5				3.5	0.5	1.0		3.5																														19.0
	16.6;	32.2;	51.3;	0	F*	310	21.9	7.7				32.3		21.9		16.1																														
81	T22S;	R39E;	S4.	(3800')	C	321	25.8	0.3				0.9	-	2.2		2.2	-	-	0.3												-															31.7
	52.7;	35.0;	10.7;	1.6	F*	311	52.7	4.8				12.8	1.3	16.8		6.5															0.5															
74b	T22S;	R39E;	S18.	(4300')	C	327	9.8	10.4	1.5			1.5	0.3	1.5		0.3	0.3		0.6			-	1.5					0.3			-															28.0
	59.7;	24.4;	15.3;	0.6	F*	146	35.6	40.4	0.7			11.0		1.4		0.7	2.1		4.1			2.1	1.4					0.7																		
30	T22S;	R39E;	S18.	(3400')	C	286	10.5	4.2	0.7			-		1.4		2.1	5.2		0.3																											23.3
	62.5;	24.4;	13.0;	0	F*	334	23.8	29.0	1.4			16.0		0.6		12.2	11.8		4.9																											
Average Substrate	49.9;	29.0;	20.2;	0.8	Average cover		13.5	3.4	0.5			1.2	0.3	1.0		1.6	0.9		0.3				0.5					0.8	0.1																	23.8
14	T22S;	R38E;	S7.	(3400')	C	245	6.5	14.3			0.4	0.8	0.8	1.2		0.4			3.2				0.4					2.0		3.7																33.7
	69.0;	23.6;	7.4;	-	F	83	19.2	42.2			1.2	2.4	2.4	3.6		1.2			9.6				1.2					6.2		10.8																
48	T21S;	R39E;	S30.	(5050')	C	202		6.2	5.0		6.4	2.0	1.5	-	4.0						2.5	-	-						2.5	1.5								-								31.8
	54.0;	31.3;	14.6;	0	F*	496		34.3	8.3		21.2	14.1	4.6	2.0	1.6						0.8	5.2	2.5						4.6	-								0.2								
56	T22S;	R38E;	S2.	(4300')	C	259	4.6	5.8	3.1	1.2		0.8	-	2.3		1.5	1.2	0.8	1.9			-	0.4														0.8									24.3
	17.9;	25.3;	41.2;	15.6	F*	296	7.8	13.9	14.9	2.7		7.8	7.1	8.5		3.0	0.3		10.8			1.0	9.5														6.1									
63	T22S;	R39E;	S4.	(3650')	C	303	0.7	12.5				5.2	-	-		-			0.3	-						-	-		0.3										-							19.0
	58.4;	23.0;	16.6;	2.0	F*	175	1.4	68.0				26.9	2.3			1.4			0.6																				4.4							
64	T22S;	R39E;	S3.	(3600')	C	268		17.5	0.3				-		2.2	0.3											-	0.7	12.3							1.9										35.2
	55.4;	32.7;	8.5;	3.7	F*	167		43.1	-				3.0		1.8	4.8											0.6		40.1							6.6										
87	T22S;	R39E;	S15.	(3650')	C	298	-	5.0	4.4	3.7	-		1.7	2.0	1.0			1.0	1.0	1.0																				1.0						21.8
	25.2;	16.6;	8.9;	49.3	F*	231	1.3	38.1	12.1	28.7	0.4		5.2	5.6	1.3			5.6	0.9	0.4																				0.4						
84	T22S;	R38E;	S13.	(4200')	C	218	4.1	14.2	3.7		0.5											0.5	2.8																						9.2	22.6
	42.0;	34.4;	23.7;	0	F	60	15.0	51.6	13.3		1.7											5.0	10.0																						3.3	
93	T22S;	R39E;	S30.	(4450')	C	238	6.7	14.2	0.4		1.3	1.6	-		2.1		0.4	-	0.4		-	-	0.4																							27.5
	54.2;	22.9;	22.0;	0.8	F*	194	13.4	58.2	2.0		4.6	4.6	0.5		6.2		2.0	4.6	0.5		1.5	1.0	1.0																							
94	T22S;	R38E;	S36.	(4800')	C	305	0.6	16.1	9.2	1.6	5.7	2.3	4.5		0.3	0.9	0.3	1.6	0.3	0.3	1.9	2.6	1.3		0.6				2.6																	52.7
	55.3;	40.3;	3.7;	0.7	F*	344	0.3	28.8	10.7	4.9	8.4	11.2	7.0			0.3	1.7	7.2			1.2	9.3	7.7		0.3				1.0																	
Average Substrate	47.9;	27.8;	16.2;	8.0	Average cover		2.6	11.7	2.9	0.7	1.6	1.4	0.9	0.6	1.1	0.3	0.2	0.4	0.8	0.1	0.5	0.3	0.6		0.1			0.1	2.0							0.2	0.1		0.1						1.0	29.8

TABLE 8: MIXED DESERT SCRUB (CONTINUED)

Number	Bare Ground; Litter; Sm. Rock; Lg. Rock	DATA	SAMPLE SIZE	LATR	HYSA	GRSP	ERFApo	EULA	ACSP	EPNE	LYAN	LYCO	DAFR	TESP	HACO	AMDU	SAME	YUBE	STSP	ORHY	POSC	SIHY	OPBA	OPEC	ATPO	ATCA	ATCO	ENVI	HALI	CHTE	LEFE	ARSP	PETH	MIBI	MATO	ERIN	STePA	GUMI	ARTR	GAMA	CHVI	DEAD	PERCENT COVER
37	T21S; R38E; S24. (4920') 75.2; 23.0; 1.8; 0	C F*	294 607		2.7 0.8	10.8 20.5		2.7 7.9	1.0 4.3	0.3 0.5	2.0 2.6	0.7			4.8 44.2			0.7 1.1	2.4 10.0	- 0.5				- 0.2		- 0.2						2.7 6.5											30.8
41	T21S; R39E; S20. (5760') 74.6; 18.5; 5.3; 1.6	C F*	209 92		-	18.7 42.4	2.4 5.4		5.3 12.0	5.7 13.0		0.5 1.1		1.9 4.4	3.3 7.6			5.7 13.0												0.5 1.1													44.0
44	T22S; R38E; S25-26(5000') 35.2; 26.7; 38.1; 0	C F*	214 501		4.2 26.2	8.9 24.8		- 4.0	0.5 14.0	0.5	0.9 6.4	5.6 9.0	0.5	- 2.4	- 3.6			2.3 1.2	0.5 8.4							0.5 2.6									0.5								25.7
51	T21S; R38E; S35. (4600') 45.3; 23.6; 19.2; 12.2	C F	303 108	4.3 12.0	4.6 13.0	5.3 14.8	3.0 8.3	4.3 12.0	5.0 4.6	2.6 7.4	2.6 7.4		3.6 10.2	0.3 0.9	0.3 0.9	1.3 3.7			1.0 2.8				-							0.3 0.9					0.3 0.9								38.8
70	T22S; R38E; S12. (4350') 39.9; 12.4; 31.3; 17.4	C F	265 77		5.3 18.2	8.3 28.6		1.5 5.2	0.4 1.3			0.8 2.6	2.6 9.1						2.3 7.8	-						3.8 13.0									2.6 9.1								27.5
85	T22S; R39E; S18. (4140') 56.5; 26.2; 17.2; 0	C F*	308 266	- 0.4	3.9 19.2	7.5 22.6		0.6 18.4	0.6 6.0	-	5.5 12.0	-				- 0.4		0.3	-							0.3																10.4 21.0	29.1 (18.7 w/O dead)
82	T22S; R39E; S9. (3750') 68.1; 27.0; 4.3; 0.7	C F*	317 344	-	8.5 18.9	14.2 31.4	-	0.9 7.3	1.9 16.3	1.6 4.9	2.8 11.6	0.3	0.3 2.6	- 1.7	1.3 2.6	- 0.9				- 0.9								0.3 0.9															32.7
96	T23S; R38E; S1. (4800') 66.6; 31.4; 2.1; 0	C F*	298 211		5.0 15.6	17.2 41.7		0.3 4.3	2.0 3.3	2.1 3.4	0.7 3.8	2.7 5.7	0.3	0.3 2.4	3.4 15.6	0.3			1.3 4.7	- 0.9	- 0.5	- 1.4																					33.8
Average Substrate	57.6; 23.5; 14.9; 4.0	Average cover		0.5	4.2	11.3	0.7	1.3	2.1	1.6	1.1	1.3	0.9	0.3	1.6	0.2		1.1	0.9							0.6				0.1					0.4							1.3	32.8
42	T21S; R39E; S21. (5840') 20.7; 31.7; 13.4; 34.1	C F	94 58			1.1 1.7	14.9 24.1			7.4 12.1	1.1 1.7				8.5 13.8		1.1 1.7	1.1 1.7	3.2 5.2			4.3 6.8						2.1	9.6 15.5	2.1 3.4				1.1 1.7	1.1 1.7					1.1 1.7	1.1 1.7		60.6
80a	T22S; R39E; S8. (4000') 34.3; 36.5; 12.6; 16.6	C F*	280 348	6.8 6.3	2.1 6.9	1.4 9.5	8.2 20.4	3.9 16.7	0.7 2.0	0.4 4.6	0.7 2.9	- 2.3	2.9 3.7	1.0 2.9	1.8 6.9	0.7 0.6	0.7 0.6		- 0.3	0.7	1.4 2.3								- 0.3					0.4 1.4	2.1 4.3	1.0 2.6	- 1.1						36.9
80b	T22S; R39E; S8. (4300') 22.7; 34.1; 13.4; 29.8	C F*	310 222	-	1.0 0.9	5.4 23.4	9.3 41.0	0.3		1.6 4.5	1.0 2.3	0.6		0.6	8.4 27.5		0.3		0.3		0.6 0.5																						29.4
69	T22S; R38E; S12. (5000') 31.1; 42.6; 8.2; 18.0	C F*	362 252		1.4 9.4	2.8 8.0	8.8 19.0	0.3	1.7 5.6	6.1 13.6	2.5 4.8		0.6 0.9	1.4 4.3	1.7 3.7		0.8 2.8	2.8 4.5	1.9 8.8	- 0.3	- 0.3			- 0.3		1.1 4.8	1.7				0.6 1.1				- 0.3		0.3 1.1	4.4 6.5					40.9
Average Substrate	27.2; 36.2; 11.9; 24.6	Average cover		1.7	1.1	2.7	10.3	1.1	0.6	3.9	1.3	0.2	0.2	0.7	5.1	0.2	0.7	0.9	1.4	0.2	0.5	1.0				0.3	0.4	0.5	2.4	0.5	0.2			0.4	0.8	0.2	0.1	1.1		0.3	0.3		41.9
86	T22S; R39E; S18. (4130') 32.8; 33.6; 33.6; 0	C F	238 85		2.9 8.2	8.0 22.3		17.6 49.4	1.7 4.7	3.8 10.6		-																														1.7 4.7	35.7
95	T22S; R39E; S31. (4800') 33.3; 32.5; 6.3; 28.6	C F*	266 264			7.5 2.3	10.5 22.3	0.8 0.8		1.5 2.3	1.8 1.9	0.4 2.3	0.4	1.1	5.7 16.3				12.8 50.4			-												-	- 0.8								42.5
71	T22S; R39E; S7. (4400') 27.9; 17.0; 33.6; 21.4	C F	239 93		10.9 28.0			0.4 1.1	3.8 9.7			0.4 1.1	0.8 2.2			0.4 1.1			18.4 47.3	0.4 1.1						1.7 4.3										0.4 1.1	1.7 4.3						38.9
43	T21S; R39E; S21. (5900') 20.2; 27.7; 38.3; 13.8	C F	103 47			4.9 10.6	6.8 17.0	1.0 2.1		9.7 21.3	2.9 6.4				14.6 31.9				1.9 4.3			1.0 2.1								1.9 4.3													45.6

Prominent associates and their respective average and range of percent cover include Grayia spinosa 2.9 (0--9.2) percent, Eurotia lanata 1.6 (1--5.7) percent, Acamptopappus sphaerocephalus 1.4 (0 -5.2) percent, Ephedra nevadensis 0.9 (0--4.5) percent, Eriogonum fasciculatum 9.7 (0--3.7) percent cover. A total of 23 species are associated with Hymenoclea in these 9 stands.

3) Grayia spinosa-dominated stands again occur in widely scattered localities at an average elevation of 4540 ft. Substrate is similar to the former two classes, consisting mostly of sandy soils, though some have a pebbly desert pavement. Total cover in these 8 stands again shows an increase to 32.8 (25.7--44) percent, of which Grayia contributes 11.3 (5.3--17.2) percent. Prominent associates and their respective average and range of percent cover include Acamptopappus sphaerocephalus 2.1 (0.4--5.3) percent; Lycium andersonii 1.1 (0--5.5) percent, Ephedra nevadensis 1.6 (0--5.7) percent, Lycium cooperi 1.3 (0--5.6) percent, Yucca brevifolia 1.1 (0--5.7) percent, Dalea fremontii 0.9 (0--3.6) percent and Stipa speciosa 0.9 (0--2.4) percent. A total of 21 associates occur with Grayia in these 8 stands.

4) Eriogonum fasciculatum ssp. polifolium-dominated stands occur mostly on rocky ridges and at higher elevations (avg. 4785 ft) on the site. Substrate is much more rocky than previously noted stands, with an average of 27.2 percent bare ground, 36.2 percent litter, 11.9 percent small rocks and 24.6 percent large rocks. In these four stands average cover was 41.9 (29.4--60.6) percent, which was the highest cover recorded on the CGSA. Of this Eriogonum fasciculatum contributed an average 10.3 (8.2--14.9) percent. Other prominent associates and their respective average and range of percent cover include Haplopappus cooperi 5.1 (1.7--8.5) percent, Ephedra nevadensis 3.9 (0.4--7.4) percent, Hymenoclea salsola 2.7 (1.1--5.4) percent, Lycium andersonii 1.3 (0.7--2.9) percent, Stipa speciosa 1.4 (0--3.2) percent, and Tetradymia spinosa 0.7 (0--1.4) percent. Chrysothamnus teretifolius is another characteristic species in these habitats. A total of 32 species are associated with the dominant in the 4 stands.

5) Eurotia lanata-dominated stands are rare on the CGSA and only 1 was sampled on a rocky hillside near a Grayia-dominated depression. In this stand total cover was high at 35.7 percent, of which Eurotia contributed 17.6 percent. Associates were few with Grayia spinosa providing 8 percent cover, Ephedra nevadensis 3.8 percent, Hymenoclea 2.9 percent, and Acamptopappus 1.7 percent cover.

6) Stipa speciosa-dominated stands occur throughout the CGSA mostly on rocky cinder-cone slopes and on rocky ridges. Two samples made in this habitat show rocky substrates with 25 percent large rocks. Total percent cover for the two stands was a high 40.7 percent, of which Stipa speciosa contributed 15.6 percent. Associates were relatively few. On the volcanic slopes Hymenoclea and Acamptopappus were important and Atriplex canescens was subdominant. On the rocky ridges subdominants were similar to the Eriogonum fasciculatum-dominated slopes with Eriogonum, Grayia, Ephedra, Haplopappus cooperii, and Lycium andersonii being subdominant. A total of 18 species were associated with the dominant Stipa speciosa.

7) Haplopappus cooperi was "dominant" on one stand occurring on the highest rocky peak. The stand had a total cover of 45.6 percent, of which

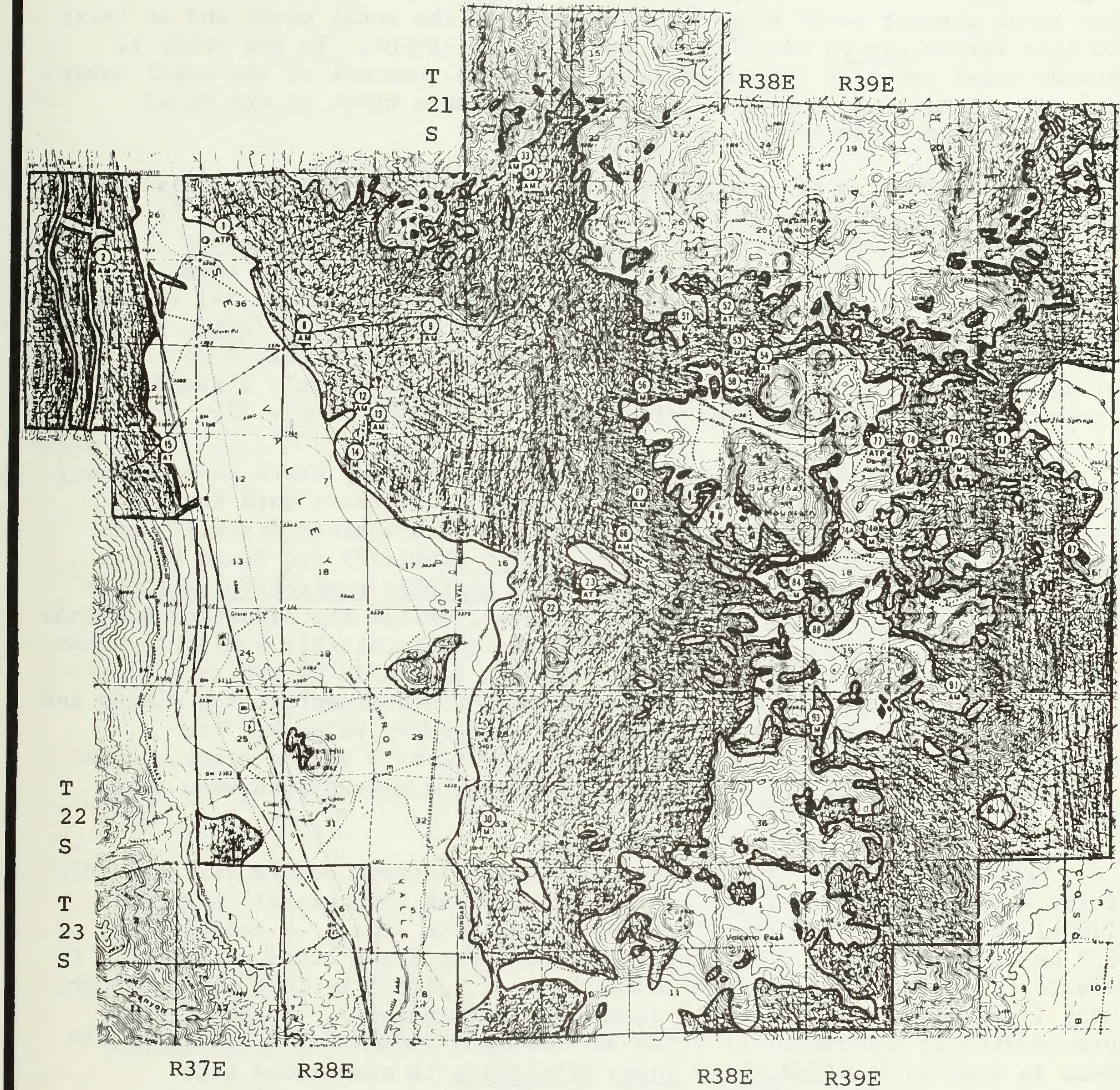
Haplopappus cooperi contributed 14.6 percent. The 8 other species each contributed over 1 percent cover. This sample was like the Eriogonum-dominated stands.

Average cover for the 31 Mixed Desert Scrub samples averaged 32.2 percent. The 16 Larrea, Hymenoclea stands had an average cover of 27.3 percent. The highest cover and greatest diversity in associates occurred in the upper rocky slopes where there is a distinct change in vegetative composition. At these higher slopes Larrea, Hymenoclea become less important while species such as Eriogonum fasciculatum, Ephedra nevadensis, Haplopappus, Stipa speciosa, Lycium andersonii, Tetradymia spinosa, Salazaria mexicana, etc. become relatively more common.

Annual herbs: There are generally fewer annuals at higher elevations in the Mojave-transition desert due to cold temperatures at the time of seedling germination and establishment (Beatley, 1976). Annuals in the higher flats among Mixed Desert Scrub vegetation develop later in the spring than those at lower elevation and in part represent those species that develop later in the season generally. In the CGSA a number of weedy annuals are much more developed at higher elevations. These include such as chess grasses (Bromus rubens, B. tectorum), Schismus grass (Schismus barbatus, S. arabicus), storksbill (Erodium cicutarium), which will often be locally dominant. Other common native-annual "wildflower" species include Chaenactis stevioides, Pectocarya setosa, and P. platycarpa, Linanthus bigelovii, Descurainia pinnata, Monardella exilis, Salvia columbariae, Gilia sp., and a number of species of Eriogonum, etc.

LARREA TRIDENTATA: Larrea tridentata (creosote bush) is present over about 148.2 km^2 (57.2 mi^2) or 50.4 percent of the CGSA (Figs. 1, 8). In over 90 km^2 (35 mi^2) it is associated with Ambrosia dumosa on sandy to rocky flats or slopes and hillsides. Over ca. 50 km^2 (19 mi^2) it is associated with Mixed Desert Scrub. Data on cover and absolute frequency are presented in Table 7 with Ambrosia dumosa and Table 8 with Mixed Desert Scrub. Other stands of Larrea are associated with Atriplex confertifolia (Table 4), Atriplex polycarpa (Table 5).

1) Larrea-Ambrosia association: Larrea seldom occurs over 1250 m (4300 ft) elevation on the CGSA. It is mostly associated, as noted above, with an Ambrosia dumosa understory where it usually shows less total cover than does Ambrosia (Table 7). Larrea is seldom in these stands but there are exceptions when Larrea is particularly large in statute. In Sample 2 (Table 7) Larrea has a cover of 25.9 percent which is 75 percent of the total 34.4 percent of the sample. Likewise in Sample 66, Larrea's cover of 20.3 percent is 69 percent of the total 29.2 percent. In the other 10 samples in Table 7 coverage of Larrea averaged only 22 percent (range 7--28%) of the total cover. Larrea occasionally forms nearly pure stands on some flats but more commonly on south-facing volcanic slopes (Samples 88, 59 at bottom of Table 7). These areas where Larrea occurs exclusive of understory components are indicated on Fig. 1 by the lack of understory color. In the other 10 stands in Table 7, Larrea has an average cover of 5.3 (1.5--8.7) percent while Ambrosia dumosa had an average cover of 9.2 (4.5--13.7) percent for all 12 stands; Ambrosia also had a much higher percent frequency as there are a greater number of smaller Ambrosia plants than Larrea. Associates with Larrea here have been discussed under the section Ambrosia dumosa.



EXPLANATION

Distribution of Larrea tridentata (creosote bush) in the CGSA. Sample sites are indicated by numbers. Subdominant species at each site is indicated by subtending letters. Quantitative data are given with understory species in Tables as indicated.

M	Mixed Desert Scrub (Table 8)
AM	*Ambrosia dumosa* (Table 7)
AT	*Atriplex confertifolia* (Table 4)
ATP	*Atriplex polycarpa* (Table 5)
---	*Larrea* exclusive (Table 7)

Figure 8. DISTRIBUTION OF CREOSOTE BUSH

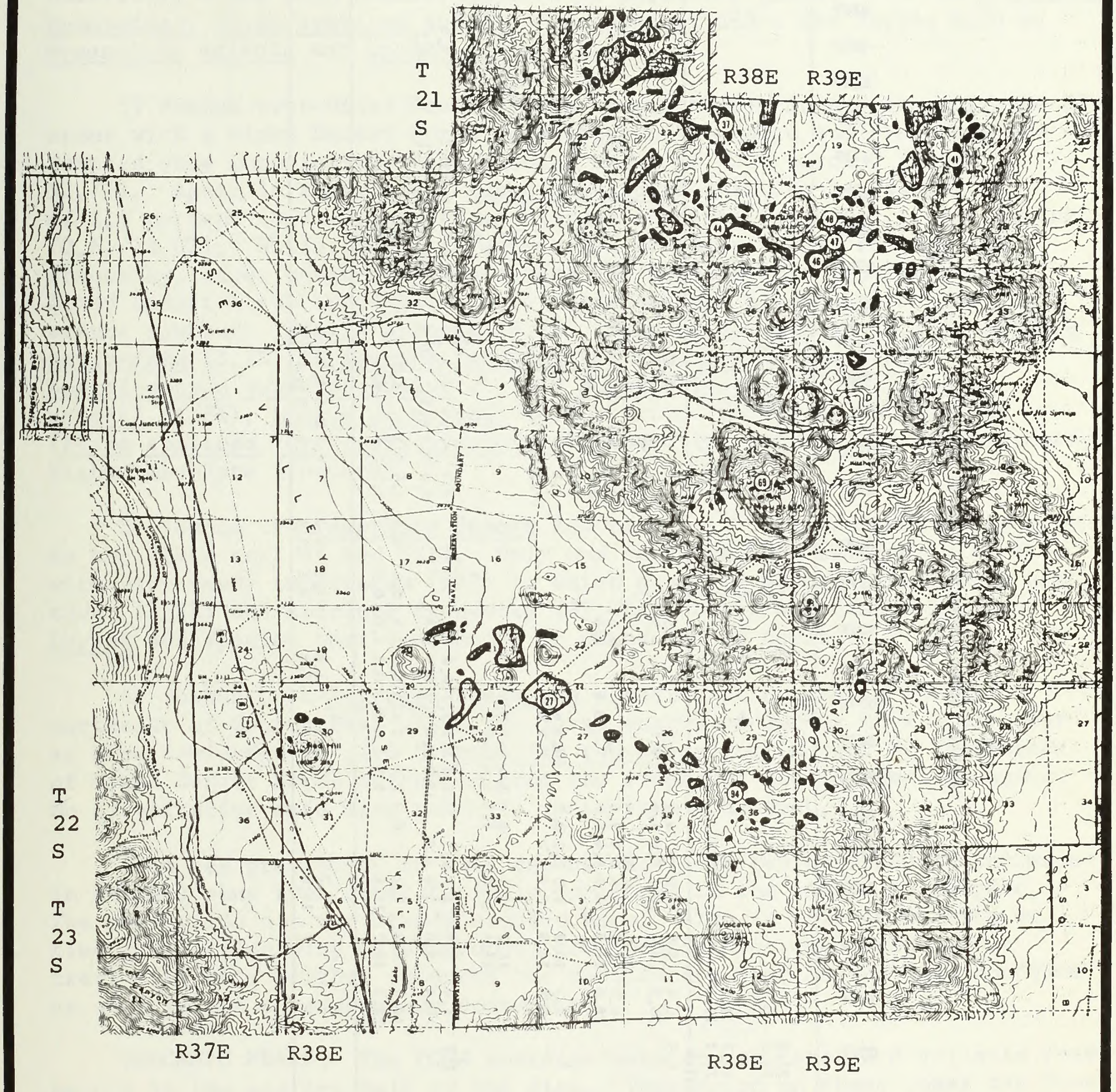
2) *Larrea*-Mixed Desert Scrub Association: *Larrea* also will have an understory of Mixed Desert Scrub (Table 8). *Larrea* occurred in 16 of the 32 stands sampled (Table 8). In the first 8 stands listed, *Larrea* has the highest percent cover of any species in the stand and in 5 of these samples the total percent cover exceeded 50 percent of the total cover and at least in this factor, *Larrea* was then dominant in the stands. In the other 11 stands total cover of *Larrea* averaged 19 (1--45) percent of the total cover and was actually not dominant. Associates were those of the Mixed Desert Scrub as discussed previously.

The association of *Larrea* with *Atriplex confertifolia* and *Atriplex polycarpa* is relatively infrequent. It is associated with only 5 of the 27 stands dominated by *Atriplex confertifolia*-*Artemisia spinescens* (Table 4). In only two of these was the cover of *Larrea* over 1 percent - once in Sample 15 - and once where *Artemisia spinescens* was dominant (Sample 54) to the exclusion of *Atriplex confertifolia*, and here the direct association of *Larrea* and *Artemisia* was not great. *Larrea* was associated with only 4 of the 15 stands dominated by *Atriplex polycarpa* (Table 5) and in only 1 stand did the frequency of *Larrea* equal that of *Atriplex polycarpa* (Sample 77).

I have previously noted that like the Joshua tree, there is a tendency to designate all vegetation containing *Larrea* as Creosote Bush Scrub. Data here shows that *Larrea* can be associated with a broad diversity of understory components, mainly *Ambrosia dumosa* (Table 7) and Mixed Desert Scrub (Table 8), and to a lesser extent with *Atriplex confertifolia* (Table 4) and *Atriplex polycarpa* (Table 5). However, unlike the situation Rowlands (1978) noted in Joshua Tree, *Larrea* is often quantitatively dominant either in cover or frequency in a particular stand. Basically *Larrea* is a widespread, tolerant species which is very common and dominant in the plains and lower fans but becomes less frequent on higher rocky bajadas. Its conspicuousness and the fact that it commonly forms a second story over an understory results in its being recognized as a dominant even when it is not.

YUCCA BREVIFOLIA: *Yucca brevifolia* (Joshua tree) occurs very sporadically over the CGSA mostly in low density over an elevational range of 1000-1750 m (3350--5800 ft). The areas mapped in Figs. 1, 9 constituting 5.2 km^2 (2.0 mi^2) or 1.7 percent of the CGSA represent areas in which Joshua tree cover is estimated to approach at least 1 percent cover, though many local and highly dispersed stands are not included. Joshua tree occurs with an assortment of shrub associates throughout its range and the same is true in the CGSA where *Yucca brevifolia* is associated with 1) shadscale, 2) Mixed Desert Scrub, 3) *Ambrosia dumosa* and 4) a mixture of *Atriplex canescens* and Mixed Desert Scrub northeast of Cactus Peak (Table 9). Substratum is mostly of fine sands or silty sands, often overlain with a pavement of small rocks. Only one sample (69) had a significant amount of large rocks. Substratum averaged 51 percent (25--86.3%) bare ground, 30 percent (18.5--42.6%) litter, 17 percent (0--43.8%) small rocks and 2 percent (0--18.0%) large rocks for the 9 samples (Table 9).

1) Joshua Tree-Shadscale Association: This combination occurs in the hills southeast and west of Cactus Peak towards the pumice mines. Two such stands (Sample 46-47) were sampled (Table 9) which showed a total cover of 22 and 25 percent with an expected low percent cover of Joshua



EXPLANATION

Distribution of *Yucca brevifolia* (Joshua tree) on the CGSA. Sample sites are indicated by numbers. See Table 9 for data.

Figure 9. DISTRIBUTION OF JOSHUA TREE

TABLE 9: YUCCA BREVIFOLIA (JOSHUA TREE).

Number	Location (Elev.) Bare Gr.; Litter; Sm. Rock; Lg. Rock	DATA	SAMPLE SIZE	YUBE	ATCO	HYSA	GRSP	ACSP	LYAN	LYCO	ERFApo	EPNE	HACO	DAFR	ATCA	LATR	AMDU	STSP	ORHY	OPEC	EULA	MATO	MIBI	SAME	TESP	LEFR	STePA	ARSP	CHTE	GUMI	ARTR	SIHY	ASLE	PERCENT COVER
	JOSHUA TREE--SHADSCALE ASSOCIATION																																	
46	T21S; R39E; S30. (4850')	O	206	1.9	22.8	-			-									-	0.5			-										-	-	25.2
	25.2; 39.6; 35.1; 0	F*	238	0.4	71.0	0.8			0.4									13.0	5.0			0.4										8.8	8.8	
47	T21S; R39E; S30. (5000')	C	193	2.6	18.1	1.0			-									-	-	0.5	-		-									-	-	22.3
	25.0: 31.2: 43.8: 0	F*	237	0.8	74.3	17.3			0.8									3.0	0.8		1.3		0.4									1.3	1.3	
	JOSHUA TREE--MIXED DESERT SCRUB ASSOCIATION																																	
48	T21S; R39E; S30. (5050')	C	202	2.5	1.5	6.4	5.0	2.0	-	4.0		1.5			2.5			-	-		6.4	-												31.8
	54.0; 31.3; 14.6; 0	F*	496	0.8	-	34.3	8.3	14.1	2.0	1.6		4.6			4.6			5.2	2.5		21.2	0.2												
44	T21S; R38E; S25-6. (5000')	C	214	2.3		4.2	8.9	0.5	0.9	5.6		0.5	-		0.5			0.5			-	0.5			-		0.5							25.7
	35.2; 26.7; 38.1; 0	F*	501	1.2		26.6	24.8	14.0	6.4	9.0			3.6		2.6			8.4			4.0				2.4									
37	T21S; R38E; S24. (4920')	C	294	0.7		2.7	10.8	1.0	2.0	0.7		0.3	4.8		-			2.4	-	-	2.7							2.7						30.8
	75.2; 23.0; 1.8; 0	F*	332	0.6		0.9	14.8	5.7	3.0			0.9	52.4					14.5	0.6	0.3	6.0							0.3						
41	T21S; R39E; S20. (5800')	C	209	5.7		-	18.7	5.3		0.5	2.4	5.7	3.3							-					1.9				0.5		-			44.0
	74.6; 18.5; 5.3; 1.6	F	92	13.0			42.4	12.0		1.1	5.4	13.0	7.6												4.4				1.1					
69	T22S; R39E; S12. (5000')	C	362	2.8	1.7	1.4	2.8	1.7	2.5		8.8	6.1	1.7	0.6	1.1			1.9	-	-	0.3	-		0.8	1.4	0.6	0.3			5.4		-		40.9
	31.1; 42.6; 8.2; 18.0	F*	352	4.5	-	9.4	8.0	5.6	4.8		19.0	13.6	3.7	0.9	4.8			8.8	0.3	0.3		0.3		2.8	4.3	1.1	1.1			6.5		0.3		
94	T22S; R38E; S36. (4800')	C	305	1.9		16.1	9.2	2.3		0.3	1.6	4.5	1.6	0.9	2.6	0.6	0.3	2.6	1.3		5.7			0.3	0.3							0.6		52.7
	55.3; 40.3; 3.7; 0.7	F*	344	1.2		28.8	10.7	11.2			4.9	7.0	7.2	0.3	1.0	0.3		9.3	7.7		8.4				1.7							0.3		
	JOSHUA TREE--BURRO WEED ASSOCIATION																																	
27	T22S; R38E; S27. (3510')	C	278	2.2				3.2				2.2		1.8		1.1	8.2		0.7	0.4	3.2													23.0
	86.3; 13.7; 0; 0	F	65	9.2				13.8				9.2		7.7		4.6	35.4		3.1	1.5	15.4													

tree averaging 2.2 percent (range 1.9--2.6%). In these two samples shadscale (Atriplex confertifolia) showed dominance in both cover (18.1--22.8%) and in absolute frequency (71--74%) and formed a rather uniform understory mixed with smaller numbers of perennial grasses such as Oryzopsis hymenoides, Stipa speciosa and Sitanion hystrix and a few shrubs such as Hymenoclea salsola and Lycium andersonii.

2) Joshua tree-Mixed Desert Scrub Association: Joshua trees frequently occur with a Mixed Desert Scrub understory on the site, and the six areas sampled show surprisingly high average cover of 37.6 percent (range 25.7--52.7%). Again in these areas Yucca brevifolia exhibits low average cover of 2.6 percent (0.7--5.7%) and an average absolute frequency of 3.6 percent (0.6--13.0%). While shadscale enters two of these stands in very low frequency, major cover components were the species also important in Mixed Desert Scrub noted below with their average percent cover for the 6 stands sampled: Grayia spinosa (9.2%), Hymenoclea salsola (5.1%), Ephedra nevadensis (3.1%), Eriogonum fasciculatum ssp. polifolium (2.9%), Acamptopappus sphaerocephalus (2.7%), Eurotia lanata (2.5%), Lycium cooperi (1.8%), Lycium andersonii (0.9%), etc. The perennial grasses (Stipa speciosa, Oryzopsis hymenoides) showed low percent but significantly higher absolute frequency.

3) Joshua tree-Ambrosia dumosa Association: This combination is present in the flats east of Red Hill. Only one such area was sampled in an area with very sandy substratum (#27) in which Ambrosia dumosa showed both high cover (8.2%) and absolute frequency (35.4%). Other associates include Larrea and species that also occur in Mixed Desert Scrub.

4) Joshua tree-Atriplex canescens association occurs in the flats northeast of Cactus Peak where two large stands of Joshua tree occur over an area dominated in part by Atriplex canescens and in part by components of Mixed Desert Scrub extending from the slopes of the adjacent mountain. No quantitative data were taken in these stands, however.

As noted previously in this report, Rowlands (1978) found no instances in which Joshua tree quantitatively dominated in the stands he sampled. The same holds for the stands sampled here. Also in this small area we find a wide diversity of understory components associated with Joshua tree. All this further supports the realization that Joshua Tree Woodland as such is not a homogeneous community.

VOLCANIC PEAKS: The CGSA contains many cinder cones and volcanic peaks, mainly in the eastern half of the site. Vegetation on these cones has been classifed as Mixed Desert Scrub (Figs. 1, 7) but vegetative cover on these slopes is usually different from that on adjacent slopes and hillsides, warranting separate discussion. Volcanic habitats are not mapped separately, but selective quantitative data is presented in Table 10.

Vegetative cover in these volcanic habitats is not uniform throughout the site, as each peak has north, east, south and western exposures and substrates range from fine sandy cinder or pumice to coarse basaltic rocky or boulder-strewn talus slopes. Vegetation cover, then, is quite variable but still certain trends are notable. For the purpose of discussion, vegetation on sandy-cindery cones will be discussed separately from that on rocky slopes.

Many of the cinder cones on the site have local or extensive areas of fine-textured cinder on the slopes. Examples are found on Red Hill near Highway 395 and an adjacent cinder hill about 1 mile to the northeast in section 20, as well as Volcano Peak, etc.

Vegetation on Red Hill varies with elevation and exposure. On the south side, cover consists of open stands of Hymenoclea salsola and Dalea fremontii. These two species continue nearly to the summit, but at higher elevations a distinctive suffrutescent sandpaper plant, Petalonyx nitidus, becomes more frequent. On the eastern and western slopes Larrea tridentata and Ambrosia dumosa become more common. Atriplex polycarpa is common on the disturbed slopes and flats where active cinder mining has occurred in the past.

The second cinder hill, ca. 1 mile northwest of Red Hill, has a cover consisting of Larrea and Ambrosia on the south and western sides, mixed with some Acamptopappus, Atriplex polycarpa and A. confertifolia, while Atriplex polycarpa is more common and conspicuous on the north side. On the eastern side Atriplex polycarpa is mixed with Larrea and some Atriplex confertifolia. Other cinder cones through the site have a similar vegetative cover. Many show rather pure stands of Larrea on the southern exposures (see Sample 88, Table 7). These areas also develop strong stands of spring annuals. DeDecker (personal communication) has indicated that the cinder cones can provide a "hot-house" effect due to their dark soil color and exposure, which, coupled with a favorable water-holding capacity can result in a favorable habitat for rapid development of annuals.

Rocky slopes are more frequently encountered on volcanic cones in the CGSA. Most have some soil development on the site but at the base consist often of large angular boulders of basaltic rocks. Vegetation over some of these is very open and often rather clumped. Several of these slopes were quantitatively sampled (Table 10). As can be seen in the data, total vegetative cover averaged 26.4 percent with a range of 16.1 to 38.0 percent for the 5 sites. This was high mainly because sampling was conducted in areas with a notable vegetative cover. In most of these rocky slopes vegetation consists of components of Mixed Desert Scrub. Atriplex canescens, as noted previously, is common on volcanic slopes, often forming locally dense stands near the base of the slopes among larger boulders. Also very common is needle grass (Stipa speciosa) (see Samples 62, 71) which may form nearly pure stands on some southerly exposures. Eriogonum inflatum is another commonly encountered species on these slopes. Other common shrub associates include Hymenoclea salsola, Grayia spinosa, Euorotia lanata, Acamptopappus, Mirabilis bigelovii, Lycium cooperi, and Dalea fremontii, all species of Mixed Desert Scrub, but their density will vary greatly from slope to slope and from cone to cone.

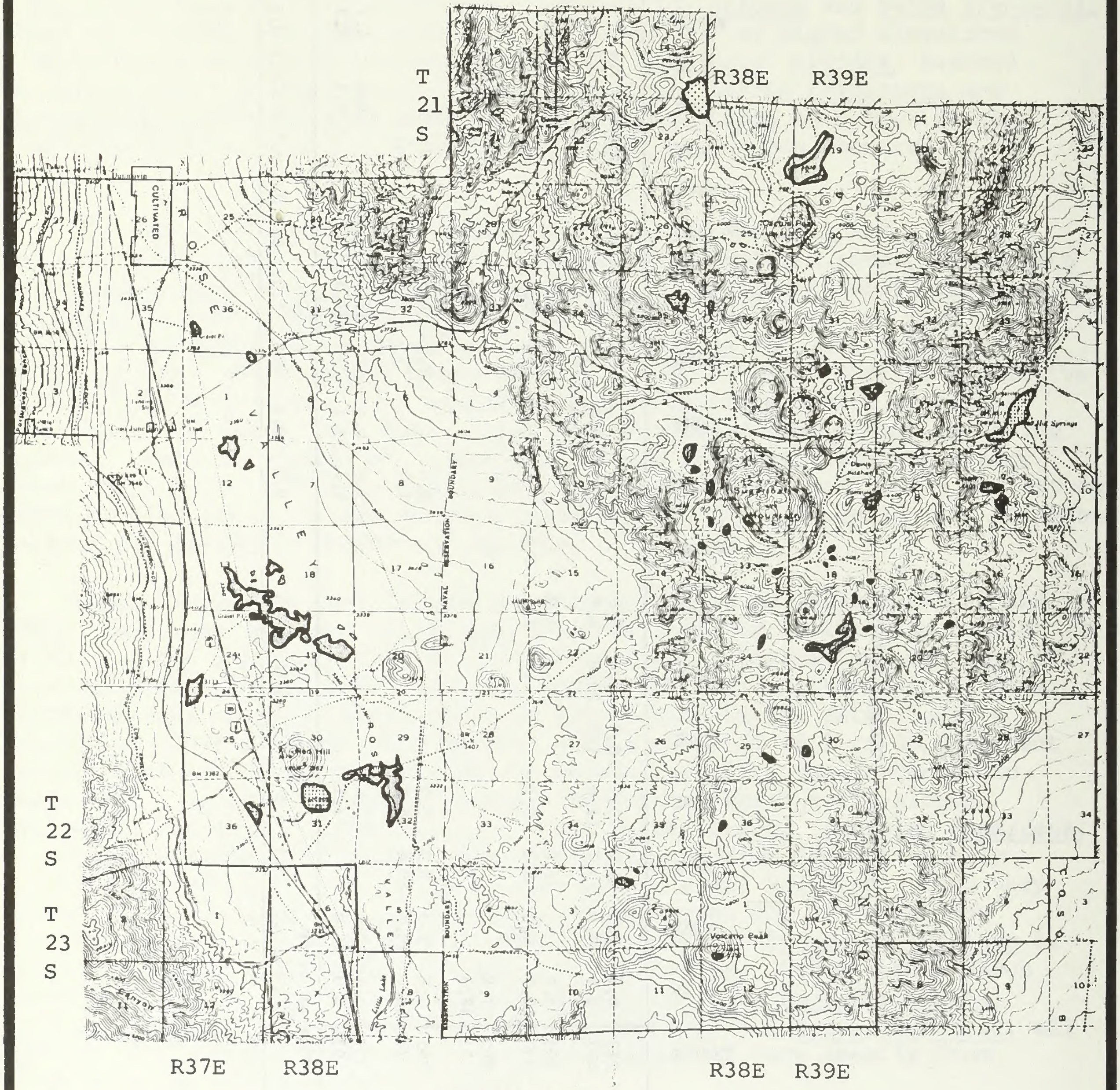
Vegetation on the tops of these cones and mountains consists of Mixed Desert Scrub (see Samples 14-43, 69 in Table 8).

DISTURBED, CULTIVATED, OPEN AND BARREN AREAS: The CGSA contains many areas devoid of a natural overstory of shrubs. These can be classified as 1) disturbed areas, 2) cultivated areas, 3) open areas, and 4) barren areas. In total they occupy about 7.2 km^2 (2.8 mi^2) or 2.4 percent of the CGSA (Fig. 10).

1) Disturbed areas are zones directly disturbed by man and his machines that have not completely recovered from this disturbance. These sites include areas of housing and development, as near Coso Junction, the Lewis Ranch, Sykes, the cinder pits south of Red Hill and other gravel and pumice

TABLE 10: VOLCANIC HABITATS

Number	(Location) (Elev.) Bare Ground; Litter; Sm. Rock; Lg. Rock	DATA	SAMPLE	ATCA	HYSA	GRSP	EULA	EPNE	HACO	LYAN	ERFApo	ACSP	AMDU	MATO	STSP	ORHY	POSC	SIHY	ERIN	MIBI	STePA	LYCO	DAFR	PERCENT COVER
45	T21S; R38E; S25. (4850')	C	213	6.6	2.3	5.2	2.3	0.9	3.8	0.9		-	-		5.6		0.5	0.5	0.5	1.4		-		31.0
	9.0; 41.2; 7.1; 25.6	F*	477	1.9	9.0	5.2	16.6	1.0	29.8	6.1		2.1	0.4'		19.3				1.9	1.5		0.2		
61	T22S; $39E; S6. (4600')	C	203	6.9	-	2.0	-			1.0	-			-	4.9			0.5	1.5	2.0	-			18.7
	2.5; 20.8; 20.8; 55.9	F*	337	12.5	0.3	8.3	6.2			7.1	0.6			0.3	46.9			0.9		11.0	4.2			
62	T22S; R39E; S6. (4400')	C	205	7.8											5.4			0.5	1.5	0.5			0.5	16.1
	1.0; 35.5; 18.2; 45.3	F	33	48.5											33.3			3.0	9.1	3.0			3.0	
70	T22S; R38E; S12. (4350')	C	265	3.8	5.3	8.3	1.5					0.4		2.6	2.3	-						0.8	2.6	27.5
	39.9; 12.4; 31.7; 17.4	F	77	13.0	18.2	28.6	5.2					1.3		9.1	7.8							2.6	9.1	
71	T22S; R39E; S7. (4400')	C	239	1.7	10.9		0.4					3.8	0.4		18.4	0.4			0.4		1.7	0.4	0.8	38.9
	27.9; 17.0; 33.6; 21.4	F	93	4.3	28.0		1.1					9.7	1.1		47.3	1.1			1.1		4.3	1.1	2.2	
	Average Substrate 16.0; 25.4; 22.3; 33.1		Average cover	5.3	3.7	3.1	0.8	0.2	0.8	0.4		0.8	0.1	0.5	7.3	0.1	0.1	0.3	0.8	0.8	0.3	0.2	0.8	26.4



EXPLANATION

Distribution of disturbed, cultivated, open and barren areas in the CGSA.

Disturbed areas (coarse dots)
Cultivated areas (so noted)
Open flats (shaded)
Barren flats (fine dots)

Some disturbed areas have been heavily revegetated; these are not shown in Figure 1.

Figure 10. DISTURBED, CULTIVATED, OPEN AND BARREN AREAS

pits throughout the site, as well as the Coso Test Well Site 1 and the Coso Hot Springs area. In addition, the numerous roads that traverse the site are included in this category. Recovery of native vegetation in these sites is dependent on substrate and the degree of continued disturbance.

Around habitations, several trees have been planted. At the Coso Junction Rest Stop a total of 21 large cottonwood trees (*Populus fremontii*) have been planted long ago and now average 21 (18--24) inches in trunk diameter. Twenty-two additional trees occur between the north and southbound lanes which average 15 (4--18) inches in diameter. In addition to the above, 71 cottonwood saplings, 12 mulberry (*Morus* sp.) and 13 *Pithecellobium* cf. *arboreum* trees have been recently planted on the site.

Just west of Coso Junction there is a house at 3370 ft elevation with a number of cultivars including 13 locust (*Robinia pseudoacacia*), 2 *Tamarix* sp., 5 clumps of common reed (*Phragmites australis*), 2 seep willow (*Baccharis glutinosa*), 5 *Caesalpinia gilliesii*, 11 small pine trees (*Pinus* sp.), 21 Italian cypress, 2 sycamore (*Platanus* sp.), 1 maple (*Acer* cf. *saccharum*) and 1 cottonwood tree.

Other mature cottonwoods have been cultivated at the Lewis Ranch on the western border of the CGSA at 3800 ft elevation. In addition, the Lewis Ranch contains stands of grape (*Vitis* sp.), Tamarisk (*Tamarix* sp.), mulberry (*Morus* sp.) to 70 ft tall, and several apricot or peach trees. Some Italian cypress (*Cupressus* sp.) and elm (*Ulmus* sp.) are cultivated at the Rose Valley Ranch.

Other disturbed areas such as the gravel, pumice and cinder pits are in a stage of recovery from past disturbance. The most commonly encountered species recolonizing these areas are *Atriplex polycarpa*, *Atriplex confertifolia* and *Hymenoclea salsola*--often the same species present before disturbance. However, a number of weedy species are often present soon after the disturbance including Russian thistle (*Salsola iberica*), and sand bur (*Ambrosia acanthicarpa*). *Atriplex polycarpa* is also common in some disturbed areas, as along Los Angeles aqueduct and in a few other areas in the CGSA (see Fig. 5).

Other large disturbed areas occur around the Coso Hot Springs where a diversity of weedy annuals are abundant in the spring, including storksbill (*Erodium cicutarium*), schismus grass (*Schismus barbatus*), six-week fescue (*Festuca octoflora*), six-week gramma (*Bouteloua barbata*), two species of *Calyptridium* (*C. parryii* ssp. *nevadense* and *C. monandrum*), and a number of other species including *Pectocarya platycarpa*, *Pectocarya setosa*, *Spergularia bocconii*, *Lepidium lasiocarpum*, *Descurainia pinnata* ssp. *glabra*, *Plagiobothrys arizonicus*, *Lepidium flavum*, *Eriogonum gracillimum*, and *Euphorbia micromeria* and the perennial *Euphorbia albomarginata*.

2) Cultivated areas: The only cultivated area in the CGSA is the alfalfa field at Rose Valley Ranch, which at the time of the survey consisted of about 310 acres; 11 acres have since been added to the fields. The tract is irrigated from late March-early April to October each year.

3) Open flats: Open flats are common in the hills in the eastern half of the CGSA. These flats represent local depressions from which shrubby

species are excluded probably by edaphic factors. Often they are surrounded by *Atriplex canescens* and in many instances they are very local consisting of less than one acre in extent. Vegetation on the flats is variable from area to area but commonly they develop stands of various wildflowers in the spring as *Lepidium flavum*, *Linanthus aureus*, *Bromus rubens*, *Bromus tectorum*, *Coreopsis californicus*, *Pectocarya* ssp., *Monardella*, *Lupinus odoratus*, etc. Later in the summer annual buckwheats become prominent, including *Eriognum trichopes*, *E. nidularium*, *E. maculatum*, *E. brachyanthum*, *E. deflexum* var. *deflexum* and sometimes *Chorizanthe thurberi*, *Oxytheca perfoliata*, *Eriastrum wilcoxii* and *Lessingia lemmonii* var. *ramulosissima*. Common perennials include *Euphorbia albomarginata*, *Astragalus lentiginosus* and *Eriogonum inflatum*.

4) Barren areas: Barren areas or playas have developed along the central drainage of Rose Valley. These sites are without vegetation in several areas and have a surface of clay which forms polygonal fissures when dry. The periphery of these depressions usually contains stands of *Atriplex polycarpa*, though in several areas *Atriplex canescens* and *A. confertifolia* were also present. Vegetation in these areas seems to be responding to slight changes in elevation as even slight rises will contain vegetation while adjacent depressions are devoid of cover.

HAIWEE SPRING: While Haiwee Spring is off the CGSA, it is included in this report, as it is a biologically significant area possibly subject to impact. Haiwee Spring is located at ca. 1450 m (4750 ft) and flows for about 0.4 km (0.25 mi) below the source. Over this area a well-developed riparian vegetation has developed consisting primarily of willows (*Salix lasiandra* var. *abramsii*, *S. lasiolepis* var. *bracelinae*) which form a gallery ca. 3--6 m high along the flowage. Mixed with willows are shrubs of seepwillow (*Baccharis glutinosa*), desert grape (*Vitis girdiana*) and a number of aquatic herbs including Parish's spike rush (*Eleocharis parishii*), wrinkled rush (*Juncus rugulosus*), Iris-leaved rush (*Juncus xiphioides*), mexican rush (*Juncus mexicanus*), water cress (*Rorippa nasturtium-aquaticum*), beardgrass (*Polypogon monspeliensis*) and water parsnip (*Berula erecta*).

In slightly drier peripheral sites species composition changes considerably. Common shrubs include the great basin sage (*Artemisia tridentata*), four-winged saltbush (*Atriplex canescens*), rabbit bush (*Chrysothamnus nauseosus* ssp. *mohavensis*), bush lupine *Lupinus excubitus* var. *excubitus*), shrubby groundsel (*Senecio douglasii*) and gum-leaved brickellia (*Brickellia multiflora*). In addition there are a number of suffrutescent species such as wormwood (*Artemisia douglasii*), horehound (*Marrubium vulgare*), narrow-leaved milkweed (*Asclepias fascicularis*); grasses such as the small-flowered melica (*Melica imperfecta* var. *refracta*) and deer grass (*Muhlenbergia rigens*); and such herbs as the scarlet monkey-flower (*Mimulus cardinalis*), cocklebur (*Xanthium strumarium*), hoary nettle (*Urtica holosericea*) and horseweed (*Conyza canadensis*), etc.

Adjacent slopes and canyons contain a Mixed Desert Scrub vegetation with *Lycium cooperi*, *L. andersonii*, *Grayia*, *Ephedra nevadensis*, *Eriogonum fasciculatum*, *Haplopappus cooperi*, *Tetradymia spinosa*, *Salazaria*, etc.

No quantitative data was taken at this site. All species encountered in the area are included in the checklist of vascular plants.

LITTLE LAKE AND LOWER PONDS: Little Lake is also not on the CGSA proper but is an area of high biological significance that could be affected by activities in the CGSA. The Little Lake area consists of Little Lake proper and two ponds at lower elevations to the south into which the Little Lake overflow runs. A total of 4 intergrading habitats are represented in this area; 1) submerged aquatic habitats, 2) emergent aquatic habitats, 3) moist to dry saline (alkaline?) flats, 4) disturbed, pastured flats.

1) Submerged aquatic habitats occur in the Lake and ponds proper. Four species of vascular plants were recorded from these ponds and the interconnecting flowages. Two species of pondweeds (*Potomogeton latifolius* and *P. pectinatus*) and a green algae (*Chara* sp.) were common in Little Lake. Horned pondweed (*Zannichellia palustris*) was collected in the channels between the ponds below Little Lake where ditch-grass (*Ruppia maritima*) has been collected by Thorne.

2) Emergent aquatic habitats occur around the shallow periphery of both ponds and Little Lake where the plants have their roots in water but vegetatively emerge above the water. The extent and development of these habitats is dependent on topography and grazing; they are best developed in shallow wet areas, as along the eastern margin of Little Lake.

The more commonly encountered emergent species are monocots such as three-square (*Scirpus americanus*, *S. olneyi*), bulrush (*Scirpus acutus*, *S. paludosus*) and various rushes (*Juncus mexicanus*, *J. rugulosus*) as well as cat-tail (*Typha latifolia*) and the common reed grass (*Phragmites australis*). Parish's spikerush (*Eleocharis parishii*) is also common while the desert cordgrass (*Spartina gracilis*) is rare and found only along the western margin of Little Lake. In many areas where grazing has occurred or the transition from upland to aquatic habitats is abrupt, no erect emergent aquatics occur and vegetation consists of salt grass (*Distichlis spicata* var. *stricta*) and yerba mansa (*Anemopsis californica*) which continues into the adjacent flats. Other plants occurring around the margins of ponds and wet areas include tamarisk (*Tamarix* cf. *parviflora*), arroyo willow (*Salix lasiolepis* var. *lasiolepis*), loosestrife (*Lythrum californicum*), water parsnip (*Berula erecta*) and beard-grass (*Polypogon monspeliensis*).

3) Moist to dry saline (alkaline?) flats surround the lakes and ponds and rather extensive flats occur between Little Lake proper and the lower ponds. These flats are mostly covered with a low, matted vegetation dominated by salt grass (*Distichlis spicata* var. *stricta*). These salt grass flats or meadows have a wet phase and a dry phase. In the wetter microhabitats, usually of lower elevation, the salt grass is mixed with such species as yerba mansa (*Anemopsis californica*), nitrophila (*N. occidentalis*), Mexican rush (*Juncus mexicanus*) and occasionally spikerush (*Eleocharis parishii*). Less, or locally, frequent are populations of butter cup (*Ranunculus cymbalaria* var. *saximontanus*), cleomella (*Cleomella parviflora*), sedge (*Carex subfusca*), arrowscale (*Atriplex phyllostegia*) and *Hutchinsia procumbens*. In drier areas the soil is covered with a layer of salt. *Distichlis* is still dominant but other species are occasional, including the shrubby alkali aster (*Aster intricatus*), a golden rod-like *Haplopappus racemosus* ssp. *glomeratus*, as well as *Cleomella obtusifolia* and a number of other species (*Nitrophila*) keep the vegetation interesting. In addition to the above a number of shrubs

are scattered over the flats including allscale (*Atriplex polycarpa*), saltbush (*A. lentiformis* ssp. *lentiformis*), four-winged saltbush (*Atriplex canescens*) and rabbit bush (*Chrysothamnus nauseosus* ssp. *consimilis*), etc.

4) Disturbed, pastured flats have developed mainly around the lower ponds where extensive grazing by horses has occurred. Many of the flats still contain salt grass but a number of weed species are common including bassia (*Bassia hyssopifolia*), jimson weed (*Datura meteloides*), heliotrope (*Heliotropium curassavicum* var. *oculatum*), saltbush (*Atriplex serenana*), and sand bur (*Ambrosia anthicarpa*), etc. In addition a number of saltbushes as *Atriplex polycarpa*, *A. lentiformis* ssp. *lentiformis* and rabbitbush (*Chrysothamnus nauseosus* ssp. *consimilis*) and one large cottonwood remain near these lower ponds. Tamarisk (*Tamarix parviflora*) is also common around the ponds.

No quantitative data was taken at this site. All species encountered are included in the checklist of vascular plants.

SUMMARY OF RARE, ENDANGERED AND LOCALLY ENDEMIC PLANTS

The CGSA, Haiwee Spring, Little Lake area contains no plant species, subspecies or variety noted in the U.S. Department of Interior, Fish and Wildlife Service list of Endangered and Threatened species (U.S. Dept. Interior, 1976), or in the California State DFG listing (Powell, 1974).

The California Native Plant Society (CNPS) Inventory of rare and endangered vascular plants of California (Powell 1974) lists 2 species as very rare and rare and endangered; 1 species as rare and not endangered and 3 species as not rare but of limited distribution. Additional locally rare or endemic species are also noted.

VERY RARE AND RARE AND ENDANGERED PLANTS

1. Spartina gracilis Trin. Alkali Cordgrass, Poaceae (Grass Family).

The alkali cordgrass is a native, rather stout perennial grass that is wide-ranging in western North America occurring along shores of lakes, streambanks, wet meadows and often alkaline habitats from southern British Columbia and Saskatchewan south through North Dakota to Nebraska, Kansas, northern New Mexico and central Arizona, and from eastern Washington and Oregon through eastern California and Nevada. On the site it is known from one small population on the western side of Little Lake where it occurs among three-square (Scirpus olneyi), bulrush (Scirpus acutus) in shallow water. While alkali cordgrass is common in western North America, in California it is known only from a few scattered localities in Siskiyou, Modoc, Lassen and Mono-Inyo Counties. The CNPS's REVD (Rarity, endangerment, vigor, general distribution) code for the species is 1211, in that it 1) is rare, of limited distribution in California but distributed widely enough that potential for extinction or extirpation is apparently low at present; 2) is considered endangered only over a part of its range; 1) its populations are considered stable or increasing at present; 1) it is not considered rare outside of California.

2. Pholisma arenarium Nutt. ex Hook. Pholisma, Lennoaceae (Lennoa Family).

Pholisma is a non-chlorophyllous, purple-red colored root parasite somewhat similar in habit to the broom rapes (Orobanche) but in a distinct small family. This species is largely restricted to California and northern Baja California, Mexico where it occurs in coastal sand dunes and flats from San Luis Obispo south into Baja California and inland in sandy areas from this site in Inyo County south into Baja California. On the site, Pholisma is known only from a single collection by Zembal et al.(1978) in the broad sandy drainage north of Coso Hot Springs (140 meters east of the tamarisk tree which is near the road just north of the Coso Hot Springs buildings). The population found in 1978 consisted of 14 plants over a 5 square foot area and was apparently parasitizing the roots of cheesebush (Hymenoclea salsola), the only shrub in the vicinity. This represented a new county record.

The CNPS records a REVD code of 2222 for this species, noting that 2) its occurrence is confined to several populations; 2) it is endangered in part; 2) its populations are declining; 2) it is rare outside of California.

RARE AND NOT ENDANGERED PLANTS

1. Canbya candida Parry. White Canbya, Papaveraceae (Poppy Family).

The white canbya is a diminutive annual, only 2--3 cm high, with small white flowers only 2--4 mm wide. It occurs sporadically in mostly sandy flats in Creosote Bush Scrub to Joshua Tree Woodland in the western Mojave

Desert from Walker Pass in Inyo County, to the Victorville Region in San Bernardino and Los Angeles Counties. It is known only from one collection on the sandy cinder flats south of Cinder Hill Road south of Red Hill in an area dominated with allscale (Atriplex polycarpa). It is endemic to California and the CNPS notes it as rare, of limited distribution but distributed widely enough that potential for extinction or extirpation is apparently low at present.

PLANTS NOT RARE BUT MOSTLY OF LIMITED DISTRIBUTION

1. Eschscholzia minutiflora Wats. Small-flowered Poppy, Papaveraceae (Poppy Family).

This is a close relative to the California Poppy, to which it is similar except for the very small orange-yellow flowers measuring only 6--12 mm in width. It is common in the Mojave and Sonoran Deserts from Mono County south into Baja California, Mexico, and adjacent Nevada. On the site it is common on the lower sandy flats and slopes nearly throughout the site, mostly occurring with creosote bush and shadscale. Eschscholzia covillei which is very similar but with slightly larger flowers is much more restricted in distribution in the area and on the site.

2. Stylocline micropoides Gray. Desert Nest Straw, Asteraceae (Sunflower Family).

This is a woolly grayish diminutive annual, often only 1--8 cm high with inconspicuous flowers arranged in very small heads. It is widespread in western United States, occurring in the Mojave and northern Colorado Deserts in California east to western Utah and New Mexico, where it is usually found on sandy washes and slopes at lower elevations below 4000 ft (Munz 1974). It is not uncommon on the site mostly found among creosote bush or shadscale on sandy flats.

3. Viguiera reticulata Wats. Leather-leaved Viguiera, Asteraceae (Sunflower Family).

This is a spreading subshrub from 5 to 15 dm high with rather distinct rigid, sandpapery, mostly basal leaves and yellow sun-flower-like heads. Its distribution is centered in Inyo Conuty but is known from the Avatatz Mountains in northern San Bernardino and Nye Counties, Nevada (Beatley, 1976) where it occurs mostly in gravelly washes and rocky canyons in Creosote Bush Scrub. On the site it is known from the lower northwestern slopes of Sugarloaf Mountain, and a few other cinder cones, and from the hills east of Coso Hot Springs.

ADDITIONAL RARE OR LOCALLY ENDEMIC PLANTS

These species are not listed by the California Native Plant Society as either rare or locally endemic but on the basis of our study appear to be noteworthy.

1. Euphorbia ocellata Dur. & Hilg. var. kerbyi J.T. Howell. Kerby's Spurge, Euphorbiaceae (Spurge Family).

This is a spreading annual spurge 2--8 cm high, known only from collections on fine-textured cindery eastern slopes of a cinder cone about 1.5 miles southeast of Volcano Peak at the southern border of CGSA. It may be expected elsewhere on the site. While the species E. ocellata is widespread in California, this variety, which was only described in 1975 from the Eureka Dunes (J.T. Howell 1975), is quite rare, known only from the Eureka Dunes, and one collection in Nine-Mile Canyon to the south. Interestingly the fruits and seeds of this collection are distinctly smaller than those of the Eureka Dunes and a re-evaluation of this collection may result in its elevation to specific rank.

2. Lomatium utriculatum (Nutt.) Coult. & Rose vel. aff. Common Lomatium, Apiaceae (Carrot Family).
While this is rather common on rocky slopes throughout the site, particularly in Mixed Desert Scrub, our material differs from that on the populations on the western side of the Sierra Nevada (Thorne, personal communication) and it may warrant distinct infraspecific recognition.

3. Cymopterus ripleyi barnebyi. Ripley's cymopterus, Apiaceae (Carrot Family).
This low perennial herb has not been reported from the CGSA but according to Mary DeDecker (personal communication) it is expected to border Rose Valley. It is widely distributed in sandy soil in western Nevada (Nye County) where two poorly distinguished varieties have been recognized (Beatley 1976). It has only recently been collected in California and is not listed in Munz's (1974) A Flora of Southern California. As it has not been found on the CGSA, its significance is reduced but it should be looked for.

SENSITIVE HABITATS: All desert habitats are sensitive to impact. The sensitivity stems from the slow recovery of vegetation due to low rainfall and the inherent infrequency of successful establishment of native species. However, recovery after disturbance does occur, and on the CGSA many disturbed habitats have shown some degree of recovery from past disturbances. Examples are found on the aqueduct right-of-ways, on the pumice and cinder mines and along roadcuts. The most commonly encountered shrubby species found in disturbed sites included Atriplex confertifolia, Atriplex polycarpa, Hymenoclea salsola, Chrysothamnus nauseosus, and to a lesser extent, Ambrosia dumosa, Lepidium fremontii and Larrea tridentata. Muller (1940) and Shreve (1942) have noted that in deserts the "pioneer" species are usually the species present before disturbance. Other important species in disturbed areas include such weedy annuals as Russian thistle (Salsola iberica), sand bur (Ambrosia acanthicarpa), and chess grasses (Bromus rubens, B. tectorum). Annual "wildflowers" are also common during the spring in these sites.

While there is a potential of recovery of native species in disturbed habitats, recovery rate is strongly affected by precipitation, as successful establishment of desert species is an infrequent event at best. In a holistic sense, the type of habitat disturbed is also important. Sandy plains can be easily returned to something that resembles their original condition as far as topography and general appearance are concerned, but highland rocky habitats can never be returned to their original appearance--creating a notable visual impact. Recovery potential of most of the vegetation in the CGSA is about the same with perhaps shadscale and allscale communities having a slightly better chance for successful recovery. In this regard, rocky habitats, then, are more sensitive to disturbance than are plains.

Another factor in the recovery of disturbed habitats is soil compaction. Numerous examples exist through the CGSA of soil compaction being a long-term deterrent to the re-establishment of plants. This can be noted from old automobile tracks--even after many years they remain distinct and without vegetative cover while adjacent noncompacted areas have recovered completely.

The most botanically sensitive habitats occur just outside the CGSA at Haiwee Springs and Little Lake. Both provide aquatic habitats that are rare in the Mojave Desert. Both contain associations of plants that are poorly represented in the Mojave Desert. Little Lake also has stands of the rare and endangered desert cordgrass (Spartina gracilis). The only other rare and endangered species is the Pholisma arenarium which occurs across from Coso Hot Springs in the broad wash which commensurately increases the sensitivity of this area. Other sensitive areas are those that contain the potential for the white canbya (Canbya candida) south of Red Hill (see section on Rare, Endangered and Locally Endemic Plants).

VASCULAR FLORA OF THE CGSA

A total of 385 taxa of vascular plants are known to occur in the CGSA and around Haiwee Spring and Little Lake. This number consists of 371 species with 14 additional varieties and subspecies (i.e., several species were represented by 2 or more varieties). Of the 385 taxa, 24 or 6.2 percent, are naturalized, often weedy species. A total of 93.8 percent are native taxa. The listing does not include the many cultivated species that grow around habitations on the site. Additional collections during wet years would undoubtedly increase the total number of species in the area as additional rare species are found. The checklist of vascular plants known from the CGSA follows.

VASCULAR PLANTS OF THE COSO GEOTHERMAL STUDY AREA

FILICAE - Ferns

Pteridaceae - Bracken-fern Family

Cheilanthes covillei Maxon. Coville's Lip Fern. Uncommon perennial in rocky areas and at base of boulders in Mixed Desert Scrub.

Pityrogramma triangularis (Kaulf) Maxon var. *triangularis*. Goldenback Fern. Rare perennial in rocky areas and at base of boulders in Mixed Desert Scrub.

GNETAE - Gnetum and allies

Ephedraceae - Ephedra Family

Ephedra nevadensis Wats. Nevada Joint-Fir, Mormon-Tea. Common shrubs on rocky areas, less so in deeper soils mostly in Mixed Desert Scrub.

Ephedra viridis Cov. Mountain Joint-Fir. Infrequent shrubs, mostly on rocky slopes on higher Mixed Desert Scrub.

ANGIOSPERMAE - Flowering Plants
DICOTYLEDONEAE

Amaranthaceae - Amaranth Family

**Amaranthus albus* L. Tumbleweed. Infrequent to rare naturalized annual in disturbed areas, as the Coso Hot Springs area.

Apiaceae - Carrot Family

Berula erecta (Huds.) Cov. Water-Parsnip. Infrequent but locally common perennial herb in wet areas below Haiwee Spring and around Little Lake and the ponds below.

Cymopterus panamintensis Coult. & Rose var. *panamintensis*. Panamint Cymopterus. Infrequent perennial herb on rocky slopes in Mixed Desert Scrub.

Lomatium mohavense (Coult. & Rose) Coult. & Rose ssp. *mohavense*. Mojave Lomatium. Infrequent perennial herb on upper rocky slopes and in rocky areas in Mixed Desert Scrub.

Lomatium utriculatum (Nutt.) Coult. & Rose. *vel af*. Common Lomatium. Infrequent perennial herb on rocky slopes and gravelly areas. Our specimens do not match closely those of cismontane California.

Asclepiadaceae - Milkweed Family

Asclepias erosa Torr. Desert Milkweed. Infrequent perennial herb in sandy soil throughout site, mostly near roads.

---

*Naturalized species.

Asclepias fascicularis Dcne. in A. DC. Narrow-Leaved Milkweed. Perennial herb. Infrequent at Haiwee Springs, Little Lake around lower pond, rare at Coso Hot Springs.

Asteraceae - Sunflower Family

Acamptopappus sphaerocephalus (Harv. & Gray) Gray. Goldenhead. Common shrub throughout the site, an important component of Mixed Desert Scrub at lower elevations, also in Shadscale Scrub, Creosote Bush Scrub.

Ambrosia acanthicarpa Hook. Sand-Bur. Rather weedy annual, frequent to common throughout the site mostly in disturbed areas along roads.

Ambrosia dumosa (Gray) Payne. Burro-Weed. Very common shrub, often dominant on coarse sandy flats and rocky, often south-facing slopes, less frequent in Mixed Desert Scrub.

Anisocoma acaulis T. & G. Scale Bud. Infrequent annual in sandy soil in Shadscale Scrub to Mixed Desert Scrub.

Artemisia douglasiana Bess. in Hook. Wormwood. Infrequent subshrub in moist areas at Haiwee Spring.

Artemisia spinescens D.C. Eat. Bud Sagebrush. Very common shrub in lower Shadscale flats but also present infrequently in upper slopes, mostly with Shadscale.

Artemisia tridentata Nutt. ssp. tridentata. Great Basin Sagebrush. Infrequent shrub in site, noted from Haiwee Springs area, and adjacent high ridges to the west.

Aster intricatus (Gray) Blake. Shrubby Alkali Aster. Locally frequent woody herb among saltgrass around and below Little Lake.

Baccharis glutinosa Pers. Mule-Fat. Infrequent shrub in wet areas at Haiwee Springs and Little Lake.

Baileya pleniradiata Harv. & Gray. Woolly-Marigold. Frequent annual or perennial herb in sandy areas throughout site.

Bebbia juncea (Benth.) Greene. Sweet Bush. Infrequent shrub in sandy washes.

Brickellia arguta Rob. Spear-Leaved Brickellia. Infrequent subshrub in rocky slopes and outcroppings in Mixed Desert Scrub areas.

Brickellia desertorum Cov. Desert Brickellia. Infrequent subshrub of rocky slopes and outcroppings in Mixed Desert Scrub areas.

Brickellia microphylla (Nutt.) Gray. Little-Leaved Brickellia. Frequent aromatic subshrub on rocky outcroppings and slopes in higher Mixed Desert Scrub areas.

Brickellia multiflora Kell. Gum-Leaved Brickellia. Frequent shrub at Haiwee Spring and in the arroyo near Coso Hot Springs.

Calycoseris parryi Gray. Yellow Tack-Stem. Infrequent annual on sandy slopes in lower Mixed Desert Scrub areas.

Chaenactis carphoclinia Gray. Pebble Pincushion. Rare annual with record from between Red Hill and Little Lake (DeDecker, personal communication).

Chaenactis fremontii Gray. Fremont Pincushion. Common annual throughout area from Shadscale Scrub to Mixed Desert Scrub, mostly in deeper soils, flats.

Chaenactis stevioides H. & A. var. brachypappa (Gray) Hall. Broad-Flowered Chaenactis. Common annual on flats and lower slopes throughout area.

Chaenactis stevioides H. & A. var. stevioides. Broad-Flowered Chaenactis. Infrequent annual with var. brachypappa on flats and lower slopes throughout area.

Chaenactis xantiana Gray. Xantus' Chaenactis. Infrequent annual on slopes mostly under shrubs.

Chrysothamnus nauseosus (Pall.) Britt. ssp. consimilis (Greene) Hall & Clem. Rabbit-Brush. Frequent greenish shrubs developing in distubed areas along roads.

Chrysothamnus nauseosus (Pall.) Britt. ssp. hololeucus (Gray) Hall & Clem. Rabbit-Brush. Frequent whitish shrubs along disturbed areas, roads, some arroyos.

Chrysothamnus nauseosus (Pall.) Britt. ssp. mohavensis (Greene) Hall & Clem. Rabbit-Brush. Frequent shrub, particularly common below and south of Haiwee Spring.

Chrysothamnus paniculatus (Gray) Hall. Punctate Rabbit-Brush. Infrequent shrub in sandy arroyo between Haiwee Spring to Coso Hot Springs area.

Chrysothamnus teretifolius (Dur. & Hilg.) Hall. Needle-Leaved Rabbit-Brush. Frequent shrub on higher, rocky slopes in Mixed Desert Scrub.

Chrysothamnus viscidiflorus (Hook.) Nutt. ssp. puberulus (D.C. Eat.) Hall & Clem. Sticky-Leaved Rabbit-Brush. Infrequent shrub only at higher rocky slopes.

Cirsium neomexicanum Gray. Desert Thistle. Infrequent biennial below Haiwee Spring.

Cirsium mohavense (Greene) Petr. Mojave Thistle. Infrequent perennial in rocky areas bordering Haiwee Spring.

Conyza canadensis (L.) Cronq. Horseweed. Infrequent annual below Haiwee Spring.

Coreopsis bigelovii (Gray) Hall. Bigelow Coreopsis. Infrequent annual in sandy flats and rocky slopes.

Coreopsis californica (Nutt.) H. K. Sharsmith. California Coreopsis. Common, often abundant annual on sandy plains and south-facing slopes.

Encelia virginensis A. Nels. ssp. actonii (Elmer) Keck. Action Encelia. Infrequent shrub in Mixed Desert Scrub, mostly on rocky slopes.

Eriophyllum ambiguum (Gray) Gray. Woolly Eriophyllum. Infrequent annual on sandy slopes, mostly in Mixed Desert Scrub.

Eriophyllum pringlei Gray. Pringle's Eriophyllum. Common annual on sandy flats from Shadscale Scrub to Creosote Bush Scrub.

Eriophyllum wallacei Gray. Wallace's Eriophyllum. Common annual on sandy flats from Sahdscale Scrub to Creosote Bush Scrub.

Filago arizonica Gray. Arizona Filago. Infrequent to rare annual on open flats.

Filago californica Gray. California Filago. Infrequent annual in open areas in flats.

Geraea canescens T. & G. Desert-Sunflower. Rare annual. Only one plant seen by Zembal at base of Basalt Butte.

Glyptopleura marginata D.C. Eat. [G. setulosa Gray]. Carved-Seed. Frequent annual in sandy flats in Shadscale Scrub and on south-facing slopes above Rose Valley. Most botanists would refer to this taxon as G. setulosa Gray.

Gnaphalium chilense Spreng. var. chilense. Cotton-Batting Plant, Cudweed. Infrequent annual or perennial at Haiwee Spring.

Gutierrezia microcephala (DC.) Gray. Small-Headed Matchweed. Infrequent shrub on higher slopes and peaks in Upper Mixed Desert Scrub.

Gutierrezia sarothrae (Pursh) Britt. & Rusby. Common Matchweed. Rare shrub on site, noted from slopes southeast of Devil's Kitchen.

Haplopappus cooperi (Gray) Hall. Cooper's Goldenbush. Very common shrub in Upper Mixed Desert Scrub and northerly-facing slopes throughout site.

Haplopappus cuneatus Gray. [Ericamera cuneata (Gray) McClatchie var. spathulata (Gray) Hall]. Desert Rock Goldenbush. Infrequent shrub on rocky outcroppings in Upper Mixed Desert Scrub.

Haplopappus linearifolius DC. ssp. interior Hall. Linear-Leaved Goldenbush. Infrequent shrub on rocky to steep slopes of Upper Mixed Desert Scrub.

Haplopappus racemosus (Nutt.) Torr. ssp. glomeratus (Nutt.) Hall. Racemose Pyrrocoma. Frequent perennial on saltgrass flats below Little Lake.

Hymenoclea salsola T. & G. var. salsola. [H. s. var. fasciculata (Nelson) Peterson & Payne]. Cheesebush. Very common shrub often dominant through much of the Mixed Desert Scrub, often occurring with Creosote Bush, also extending into areas of Shadscale Scrub.

*Lactuca serriola L. Wild Lettuce. Rare annual weed, one plant observed at Haiwee Spring area.

Lasthenia chrysostoma (F. & M.) Greene. Goldfields. Rare annual on sandy soils.

Layia glandulosa (Hook.) H. & A.) ssp. glandulosa. White Layia. Infrequent annual on sandy flats and south-facing sandy slopes.

Lepidospartum squamatum (Gray) Gray. Scale-Broom. Infrequent shrub in sandy washes as near Coso Hot Springs.

Lessingia lemmonii Gray var. ramulosissima (Nels.) Ferris. Vinegar-Weed. Frequent to common annual flowering in late spring-summer in sandy flats, slopes, roadsides throughout site.

Lygodesmia exigua Gray. [Prenanthella exigua (Gray) Rydb.]. Annual Lygodesmia. Rare annual on rocky hillsides.

Machaeranthera tortifolia (Gray) Cronq. & Keck. [Xylorrhiza t. (Gray) Greene]. Desert Aster. Frequent subshrub but scattered through Mixed Desert Scrub.

Malacothrix coulteri Gray. Snake's Head. Infrequent annual of sandy to rocky slopes and flats.

Malacothrix glabrata Gray. Desert-Dandelion. Common annual of sandy slopes, flats, particularly under shrubs.

Malacothrix sonchoides (Nutt.) T. & G. Sow-Thistle Malacothrix. Infrequent annual on sandy soil on slopes, flats.

Malacothrix stebbinsii Davis & Raven. Stebbins' Malacothrix. Rare annual on rocky slopes west of Coso Hot Springs.

Microseris linearifolia (DC.) Sch.-Bip. Uropappus. Infrequent annual on slopes in Mixed Desert Scrub, also in seepage area below Haiwee Spring.

Monoptilon bellidiforme T. & G. ex Gray. Desert Star. Common annual on open sandy to rocky flats, slopes.

Monoptilon bellioides (Gray) Hall. Mojave Desert Star. Infrequent annual on open sandy to rocky flats, slopes.

Nicolletia occidentalis Gray. Nicolletia. Infrequent perennial herb in sandy washes, flats.

Psathyrotes annua (Nutt.) Gray. Mealy Rosettes. Frequent annual in late spring-summer on sandy flats and slopes also at Little Lake.

Rafinesquia neomexicana Gray. Desert-Cichory. Infrequent annual on flats to slopes. Mostly growing among shrubs.

Senecio douglasii DC. var. douglasii. Shrubby Groundsel. Rare shrubs in sandy washes, as below Haiwee Spring.

Senecio douglasii DC var. monoensis (Greene) Jeps. Mono Groundsel. Infrequent subshrub with the species below Haiwee Spring. Most plants are so grazed by burros as to make identification difficult.

*Sonchus asper (L.) Hill. Sow-Thistle. Rare naturalized annual in seepage below Haiwee Spring.

Stephanomeria exigua Nutt. var. exigua. Small Stephanomeria. Frequent annual on sandy to rocky flats and slopes throughout site.

Stephanomeria parryi Gray. Parry's Stephanomeria. Infrequent annual on rocky slopes, mostly under shrubs.

Stephanomeria pauciflora (Torr.) Nutt. Wire-Lettuce. Frequent annual on rocky slopes and flats in Upper Mixed Desert Scrub areas.

Stylocline micropoides Gray. Desert Nest-Straw. Infrequent, but locally common annual of sandy flats, slopes.

Syntrichopappus fremontii Gray. Yellow Syntrichopappus. Common annual of sandy flats & slopes throughout site.

Tetradymia spinosa (H. & A.) var. longispina Jones. [T. axillaris A. Nels. var. longispina (M.E. Jones) Strother]. Cotton-Thorn. Infrequent to frequent shrub of upper flats, lower slopes from Mixed Desert Scrub to Shadscale Scrub.

Tetradymia stenolepis Greene. Mojave Cotton-Thorn. Infrequent shrub mainly at higher, rocky slopes.

Viguiera multiflora (Nutt.) Blake var. nevadensis (A. Nels.) Blake. Nevada Viguiera. Rare perennial herb, only one plant seen near Haiwee Spring on open slopes.

Viguiera reticulata Wats. Leather-Leaved Viguiera. Infrequent subshrub on rocky slopes, as the northwest slopes of Sugarloaf Mt. Listed as not rare but of limited distribution in California.

Xanthium strumarium L. var. canadense (Mill.) T. & G. Cocklebur. Infrequent annual at Haiwee Spring area and below Little Lake.

Boraginaceae - Borage Family

Amsinckia intermedia F. & M. Common Fiddleneck. Infrequent annual in flats, not observe in 1979.

Amsinckia tessellata Gray. Tessellate Fiddleneck. Frequent to common annual throughout the site but particularly on sandy soils.

Coldenia nuttallii Hook. [*Tiquilia n.* (Hook.) Richards.]. Nuttall's Coldenia. Infrequent annual on sandy soils, mostly near Shadscale Scrub vegetation.

Coldenia plicata (Torr.) Cov. [*Tiquilia p.* (Torr.) Richards.]. Plicate Coldenia. Infrequent perennial herb, recorded only near the Coso Hot Springs Area.

Cryptantha barbigera (Gray) Greene. Bearded Cryptantha. Common annual in sandy and gravelly soils particularly about shrubs.

Cryptantha circumscissa (H. & A.) Jtn. Western Cryptantha. Very common annual throughout the site in sandy and gravelly soils.

Cryptantha decipiens (Jones) Heller. Gravel Cryptantha. Frequent annual throughout the site in sandy and gravelly soils.

Cryptantha dumetorum (Greene ex Gray) Greene. Bush-loving Cryptantha. Frequent annual particularly under shrubs, in sandy soils.

Cryptantha intermedia (Gray) Greene. Common Cryptantha. Infrequent annual in sandy soil.

Cryptantha micrantha (Torr.) Jtn. ssp. *micrantha*. Purple-Rooted Cryptantha. Common annual on sandy flats and slopes, particularly in Shadscale Scrub.

Cryptantha muricata (H. & A.) Nels. & Macbr. Prickly Cryptantha. Rare annual known from herbarium record near Little Lake (DeDecker, personal communication).

Cryptantha nevadensis Nels. & Kenn. var. *nevadensis*. Nevada Cryptantha. Infrequent annual in sandy soils, usually associated with bushes.

Cryptantha nevadensis Nels. & Kenn. var. *rigida* Jtn. Infrequent annual, occurring with the typical variety.

Cryptantha pterocarya (Torr.) Greene var. *pterocarya*. Wing-Nut Cryptantha. Common annual throughout the site from sandy to rocky soils.

Cryptantha pterocarya (Torr.) Greene var. *cycloptera* (Greene) Macbr. Infrequent annual occurring with the species but much less frequent.

Cryptantha utahensis (Gray) Greene. Scented Cryptantha. Infrequent annual in sandy and gravelly soils.

Heliotropium curassavicum L. var. *oculatum* (Heller) Jtn. Heliotrope. Fleshy perennial herb frequent below Little Lake around lower ponds.

Pectocarya penicillata (H. & A.) A. DC. Winged Pectocarya. Infrequent annual in gravelly soils, recorded only from near the Coso Hot Springs.

Pectocarya platycarpa (M. & J.) M. & J. Broad-Fruited Pectocarya. Frequent annual in sandy to coarser soils throughout the area, particularly on upper elevation flats, slopes, and depressions.

Pectocarya recurvata Jtn. Recurved Pectocarya. Frequent throughout the site, often occurring with the above noted species in similar habitats.

Pectocarya setosa Gray. Bristly Pectocarya. Frequent annual throughout the site but more common in upper elevations on sandy flats.

Plagiobothrys arizonicus (Gray) Greene ex Gray. Arizona Popcorn-Flower. Infrequent annual in disturbed areas as near Coso Hot Springs.

Plagiobothrys canescens Benth. Valley Popcorn Flower. Infrequent annual in disturbed areas at Coso Hot Springs. While native to California, this species appears to be introduced at this site.

Plagiobothrys jonesii Gray. Jones' Popcorn Flower. Rare in basaltic soil northwest of Devil's Kitchen.

Brassicaceae - Mustard Family

Arabis glaucovalvula Jones. Glaucous-Valved Rock-Cress. Infrequent perennial herb in rocky areas in Upper Mixed Desert Scrub.

Arabis inyoensis Roll. Inyo Rock-Cress. Infrequent perennial herb in rocky slopes in Upper Mixed Desert Scrub.

Arabis pulchra Jones var. *gracilis* Jones. Beautiful Rock-Cress. Infrequent perennial herb in Mixed Desert Scrub.

Caulanthus cooperi (Wats.) Pays. Cooper's Caulanthus. Infrequent to frequent annual on sandy to coarser soils throughout the site.

Descurainia pinnata (Walt.) Britt. ssp. *glabra* (Woot. & Standl.) Detl. Yellow Tansy-Mustard. Very common annual throughout the site, particularly common along roadsides and in distrubed areas.

**Descurainia sophia* (L.) Webb. Tansy-Mustard. Frequent naturalized annual in sandy or coarser soils throughout the site particularly in disturbed areas.

Dithyrea californica Harv. Spectacle-Pod. Infrequent annual in sandy soils throughout the site.

Hutchinsia procumbens (L.) Desv. Procumbent Hutchinsia. Frequent delicate annual in saltgrass areas below Little Lake.

Lepidium flavum Torr. Yellow Pepper-Grass. Common annual throughout the site, particularly in depressions and in sandy areas of Shadscale Scrub.

Lepidium fremontii Wats. Fremont's Pepper-Grass. Infrequent subshrub in rocky to sandy slopes with Creosote to Mixed Desert Scrub, more frequent at higher elevations.

Lepidium lasiocarpum Nutt. Hairy-Pod Pepper-Grass. Frequent annual throughout area, particularly in disturbed areas.

Rorippa nasturtium-aquaticum (L.) Schinz & Thell. [Nasturtium officinale R. Br.]. Water-Cress. Frequent naturalized perennial in streambed below Haiwee Spring, and below Little Lake.

*Sisymbrium altissimum L. Tumble-Mustard. Infrequent naturalized annual weed around the Coso Junction rest area.

Stanleya elata Jones. Panamint Plume. Rare shrub in Mixed Desert Scrub on the site.

Stanleya pinnata (Pursh) Britt. ssp. pinnata. Desert Plume. Infrequent shrub in hills and rocky flats, mainly at higher elevations on the site.

Streptanthella longirostris (Wats.) Rydb. Streptanthella. Common fleshy annual in sandy to coarser soils, mostly among shrubs.

Thelypodium lasiophyllum (H. & A.) Greene var. utahense (Rydb.) Jeps. California Mustard. Frequent fleshy annual mostly in finer soils throughout the site, often under shrubs.

Thysanocarpus curvipes Hook. var. eradiatus Jeps. Fringe-Pod. Infrequent delicate annual on rocky slopes, mostly in Mixed Desert Scrub.

Thysanocarpus laciniatus Nutt. ex T. & G. var. hitchcockii Munz. Lace-Pod. Rare annual known from one record in lava at Little Lake (DeDecker record).

Tropidocarpum gracile Hook. Slender Tropidocarpum. Infrequent annual on open to rocky slopes in Mixed Desert Scrub.

Cactaceae - Cactus Family

Echinocactus polycephalus Engelm. & Bigel. Cottontop Cactus. Frequent succulent mostly on rocky granitic slopes in Cresote Bush to Mixed Desert Scrub.

Echinocereus engelmannii (Parry) Lem. var. chrysocentrus (Engelm. & Bigel.) Engelm. ex Rumpler. Hedgehog Cactus. Rare on rocky granitic slopes in Creosote Bush Scrub.

Opuntia basilaris Engelm. & Bigel. var. basilaris. Beavertail Cactus. Infrequent tuna cactus in sandy to coarse soils from Shadscale to higher Mixed Desert Scrub throughout the site.

Opuntia echinocarpa Engelm. & Bigel. var. echinocarpa. Silver Cholla. Frequent cholla cactus mostly in sandy to coarser soils from Shadscale to Upper Mixed Desert Scrub throughout the site.

Opuntia erinaceae Engelm. & Bigel. var. erinaceae. Mojave Prickly-Pear. Rare tuna cactus on rocky soils in Upper Mixed Desert Scrub.

Campanulaceae - Bellflower Family

Nemacladus glanduliferus Jeps. var. orientalis McVaugh. Glandular Nemacladus. Frequent in sandy soils from Shadscale to Mixed Desert Scrub. Delicate annual.

Nemacladus rubescens Greene. Desert Nemacladus. Frequent to common delicate annual on sandy soils from Rose Valley to Mixed Desert Scrub.

Nemacladus sigmoideus Robbins. Small-Flowered Nemaclauds. Frequent delicate annual on sandy soils. Common throughout the site.

Capparaceae - Caper Family

Cleomella obtusifolia Torr. & Frem. Bushy Cleomella. Frequent annual in saltgrass flats south of Little Lake and around the lower ponds.

Cleomella parviflora Gray. Small-Flowered Cleomella. Frequent delicate annual in saltgrass flats south of Little Lake.

Caryophyllaceae - Pink Family

Achyronychia cooperi T. & G. Frost Mat. Rare annual on sandy soils potentially throughout.

Arenaria macradenia Wats. var. *ferrisiae* Abrams. Sandwort. Infrequent perennial herb in rocky granitic slopes in Mixed Desert Scrub.

**Spergularia bocconii* (Scheele) Foucaud. Boccone's Sandy Spurry. Common naturalized annual in flats around the Coso Hot Springs.

Chenopodiaceae - Goosefoot Family

Atriplex canescens (Pursh) Nutt. ssp. *canescens*. Four-Winged Saltbush. Locally very common, dominant shrub in low flats and depressions, mostly in Mixed Desert Scrub. The largest stands occurring in the flats north of Cactus Peak.

Atriplex confertifolia (Torr. & Frem.) Wats. Shadscale. Very common, dominant shrub in fine soils throughout Rose Valley and in valleys north of Sugarloaf Mt. and south of Cactus Peak.

Atriplex lentiformis (Torr.) Wats. ssp. *lentiformis*. Saltbush. Frequent shrub around ponds south of Little Lake.

Atriplex phyllostegia (Torr.) Wats. Arrowscale. Frequent annual in saltgrass flats south of Little Lake.

Atriplex polycarpa (Torr.) Wats. Allscale. Frequent shrub along roadsides, becoming locally dominant in depressions, some flats, disturbed areas and in rather extensive sandy to rocky-lava flats in the southwestern sector of the area.

**Atriplex rosea* L. Redscale. Infrequent annual naturalized in pastures near ponds below Little Lake.

Atriplex sereana A. Nels. Saltbush. Frequent annual in disturbed pastures near ponds below Little Lake.

**Bassia hyssopifolia* (Pall.) Kuntze. Bassia. Frequent weedy annual in disturbed pastures below Little Lake.

Chenopodium desiccatum Nels. var. leptophylloides (J. Murr.) H.A. Wahl. Goosefoot. Infrequent annual in disturbed roadside areas throughout the site.

Chenopodium californicum (Wats.) Wat.s California Goosefoot. Infrequent perennial in rocky areas at higher elevations.

Chenopodium fremontii Wats. Fremont's Goosefoot. Rare annual below Haiwee Spring.

Chenopodium incanum Heller. Pigweed, Goosefoot. Infrequent annual, mostly in disturbed places and roadsides.

Chenopodium rubrum L. Red Goosefoot. Rare erect annual in saline marsh at Little Lake (Thorne record).

Eurotia lanata (Pursh) Moq. [Ceratoides lanatum (Pursh) J.T. Howell]. Winter Fat. Frequent in Mixed Desert Scrub, rarely becoming locally dominant on rocky hillsides.

Grayia spinosa (Hook.) Moq. Hop-Sage. Common perennial in Mixed Desert Scrub where often locally dominant.

Monolepis nuttalliana (Schult.) Greene. Patata. Infrequent annual on clay-silty soils.

Nitrophila occidentalis (Nutt.) Moq. Nitrophila. Locally common succulent perennial in saltgrass flats around and south of Little Lake.

*Salsola iberica Sennen & Pau. Russian-Thistle. Frequent naturalized annual in disturbed areas as along roadsides throughout the site.

Convolvulaceae - Morning-Glory Family

Cuscuta denticulata Engelm. Toothed Dodder. Frequent parasitic annual in Shadscale Scrub, less frequent in Mixed Desert Scrub.

Cuscuta indecora Choisy. Pretty Dodder. Infrequent parasitic annual at Little Lake on Anemopsis californica. (Thorne record).

Cuscuta nevadensis Jtn. Nevada Dodder. Infrequent parasitic annual in Shadscale Scrub.

Cuscuta salina Engelm. Alkali Dodder. Infrequent parasitic annual at Little Lake on Atriplex phyllostegia. (Thorne record).

Cucurbitaceae - Gourd Family

Cucurbita palmata Wats. Coyote Melon. Rare perennial in sandy wash north of Coso Hot Springs.

Euphorbiaceae - Spurge Family

Eremocarpus setigerus (Hook.) Benth. Dove Weed. Infrequent annual in sandy slopes in Mixed Desert Scrub. Flowering late in summer.

Euphorbia albomarginata T. & G. Rattlesnake Weed. Common low perennial herb throughout site from Shadscale to Mixed Desert Scrub and in flats.

Euphorbia micromeria Boiss. Sonoran Sand-Mat. Infrequent annual in flats throughout site.

Euphorbia ocellata Dun. & Hilg. var. *kirbyi* J.T. Howell. Cinder Sand Mat. Rare annual found on the east side of cinder cone southeast of Volcano Peak.

Euphorbia setiloba Engelm. Bristle-Lobed Sand-Mat. Infrequent annual in flats, noted only near Coso Hot Springs.

Euphorbia vallis-mortae (Millsp.) J.T. Howell. Indian Spurge. Rare perennial herb known from areas both north and south of the CGSA and therefore expected within (DeDecker, personal communication).

Stillingia paucidentata Wats. Mojave Stillingia. Infrequent perennial herb, locally common on sandy soils.

Fabaceae - Pea Family

Astragalus acutirostris Wats. Beaked-Rattle-Weed. Infrequent annual on rocky flats and slopes.

Astragalus didymocarpus H. & A. var. *didymocarpus*. Common Dwarf Locoweed. Infrequent annual in Creosote Bush Scrub in sandy or coarser soils.

Astragalus didymocarpus H. & A. var. *dispermus* (Gray) Jeps. Common Dwarf Locoweed. Infrequent with the type variety.

Astragalus lentiginosus Dougl. var. *variabilis* Barneby. Mottled Rattleweed. Common in sandy and relative fine soils throughout the site, particularly common in Shadscale Scrub.

Astragalus purshii Dougl. var. *tinctus* Jones. Pursh's Woolly Pod. Infrequent perennial herb on rocky hillsides in Mixed Desert Scrub.

Dalea fremontii Torr. var. *minutifolia* (Parish) L. Benson. [*Psorothamnus arborescens* (Torr.) Barneby var. *minutifolius* (Parish) Barneby]. Frequent throughout site more common on coarse sandy soils and hillsides.

Lotus humistratus Greene. Hill Lotus. Frequent to infrequent annual in sandy flats mostly below the Mixed Desert Scrub.

Lotus procumbens (Greene) Greene. Pale-Leaved Deer-Weed. Rare low subshrub known only in the wash near Coso Hot Springs.

Lotus rigidus (Benth.) Greene. Desert Lotus. Rare on rocky slopes.

Lotus strigosus (Nutt. in T. & G.) Greene. Stiff-Haired Lotus. Infrequent annual in sandy, often disturbed areas.

Lupinus bicolor Lindl. ssp. _microphyllus_ (Wats.) D. Dunn. Pygmy-Leaved Lupine. Infrequent annual in sandy to coarser soils.

Lupinus brevicaulis Wats. Short-stemmed Lupine. Rare annual in gravelly soils.

Lupinus concinnus Agardh. ssp. _orcuttii_ (Wats.) D. Dunn. Elegant Lupine. Frequent annual on sandy flats to rocky slopes.

Lupinus densiflorus Benth. var. _lacteus_ (Kell.) C.P. Sm. Dense-Flowered Lupine. Infrequent annual on sandy flats.

Lupinus excubitus Jones var. _excubitus_. Interior Bush Lupine. Infrequent but locally common shrub observed on rocky slopes of Sugarloaf Mt., and other cinder cones and near Haiwee Spring.

Lupinus odoratus Heller. Mojave Lupine. Frequent to common annual in sandy flats throughout site.

Lupinus shockleyi Wats. Shockley's Lupine. Infrequent annual on sandy flats.

Lupinus subvexus C.P. Sm. Intermediate Lupine. Infrequent annual on flats.

*_Melilotus albus_ Desr. White Sweet-Clover. Naturalized annual locally frequent in wet areas, as below Haiwee Spring and south of Little Lake.

*_Melilotus indicus_ (L.) All. Yellow Sweet-Clover. Infrequent annual in sandy washes.

Geraniaceae - Geranium Family

*_Erodium cicutarium_ (L.) L'Her. Filaree. Naturalized annual common throughout the site.

Erodium texanum Gray. Texas Filaree. Rare annual above Fossil Falls, north of Little Lake (DeDecker record).

Hydrophyllaceae - Waterleaf Family

Emmenanthe penduliflora Benth. Whispering Bells. Infrequent annual on rocky, sandy slopes.

Eucrypta chrysanthemifolia (Benth.) Greene var. _bipinnatifida_ (Torr.) Const. Common Eucrypta. Infrequent on rocky slopes and outcrops.

Eucrypta micrantha (Torr.) Heller. Desert Eucrypta. Infrequent on rocky slopes and rocky outcrops.

Nama aretioides (H. & A.) Brand. Purple Nama. Rare annual herb south of Red Hill and Cinder Cone Road (DeDecker record).

Nama demissum Gray var. _demissum_. Purple Mat. Common annual on sandy flats, slopes throughout the site.

Nama demissum Gray var. deserti Brand. Purple Mat. Common on sandy flats and slopes with the type variety. Doubtfully distinct from the type variety.

Nama depressum Lemmon ex Gray. Narrow-Leaved Nama. Infrequent annual of sandy flats.

Nemophila menziesii H. & A. ssp. integrifolia (Parish) Munz. Baby Blue-Eyes. Rare annual on rocky slopes.

Phacelia bicolor Torr. ex Wats. Two-colored Phacelia. Rare annual herb in Coso Hot Springs (DeDecker record).

Phacelia crenulata Torr. var. crenulata. Heliotrope Phacelia. Infrequent annual on flats and slopes throughout.

Phacelia cryptantha Greene. Limestone Phacelia. Infrequent annual on slopes, often growing among bushes.

Phacelia curvipes Torr. ex Wats. Washoe Phacelia. Infrequent annual on gravel flats.

Phacelia distans Benth. Wild-Heliotrope. Common annual on slopes, often growing through shrubs.

Phacelia fremontii Torr. Fremont's Phacelia. Common on sandy flats and slopes throughout area.

Phacelia ramosissima Dougl. ex Lehm. var. suffrutescens Parry. Branching Phacelia. Infrequent perennial herbs in rocky canyons.

Phacelia rotundifolia Torr. ex Wats. Round-Leaved Phacelia. Infrequent annual in crevices of rocks in canyon areas.

Phacelia tanacetifolia Benth. Tansy Phacelia. Rare annual in Rose Valley (M.A. Henry record; DeDecker, personal communication).

Phacelia vallis-mortae J. Voss var. vallis-mortae. Death Valley Phacelia. Frequent annual, usually growing among shrubs.

Pholistoma membranaceum (Benth.) Const. White Fiesta-Flower. Rare annual herb in Fossil Falls area (DeDecker record).

Tricardia watsonii Torr. ex Wats. Three-Hearts. Infrequent perennial herb mostly growing under shrubs in Shadscale to Mixed Desert Scrub.

Lamiaceae - Mint Family

*Marrubium vulgare L. Horehound. Naturalized perennial herb persisting at Haiwee Spring, near Coso Hot Springs and south of Little Lake.

Monardella exilis (Gray) Greene. Mojave Pennyroyal. Common annual in sandy areas developing late in the spring.

Salazaria mexicana Torr. Bladder-Sage. Moderately frequent shrub in Mixed Desert Scrub and in washes.

Salvia carduaceae Benth. Thistle Sage. Infrequent annual in sandy to gravelly slopes and flats.

Salvia columbariae Benth. var. columbariae. Chia. Frequent annual on sandy and coarser flats and slopes throughout site.

Salvia dorrii (Kell.) Abrams ssp. dorrii. Gray-Ball Sage. Infrequent shrub on rocky slopes and margins of washes.

Lennoaceae - Lennoa Family

Pholisma arenarium Nutt. ex Hook. Pholisma. Fleshy root parasite, rare in the wash east of Coso Hot Springs, growing on Hymenoclea salsola. Listed as very rare and endangered by the California Native Plant Society.

Lythraceae - Loosestrife Family

Lythrum californicum T. & G. California Loosestrife. Locally common woody perennial herb in wet areas around the ponds below Little Lake.

Loasaceae - Stick-Leaf Family

Eucnide urens Parry. Rock-Nettle. Rare Perennial herb in crevices on basaltic cliffs east on Little Lake.

Mentzelia albicaulis (Hook.) T. & G. Small-Flowered Blazing Star. Frequent annual mostly in sandy to coarser soils throughout site.

Mentzelia tridentata (David.) Thompson & Roberts. Desert Stick-Leaf. Infrequent on cinder slopes of Red Hill.

Mentzelia veatchiana Kell. Veatch's Stick-Leaf. Frequent annual from sandy to rocky slopes throughout site.

Petalonyx nitidus Wats. Shining Sandpaper Plant. Frequent subshrub on upper rocky to cinder slopes of cinder cones throughout the site.

Petalonyx thurberi Gray ssp. thurberi. Thurber's Sandpaper Plant. Frequent subshrub in sandy washes, as below Haiwee Spring.

Malvaceae - Mallow Family

Eremalche exilis (Gray) Greene. White Mallow. Common annual on sandy flats, slopes.

Eremalche rotundifolia (Gray) Greene. Desert Fivespot. Infrequent on rocky slopes.

Sphaeralcea ambigua Gray ssp. ambigua. Desert Mallow. Frequent perennial herb throughout the site.

Nyctaginaceae - Four-O'Clock Family

Abronia pogonantha Heimerl. Mojave Sand-Verbena. Common annual on sandy flats, slopes throughout the site.

Mirabilis bigelovii Gray var. *retrorsa* (Heller) Munz. Wishbone Bush. Infrequent subshrub mostly on rocky slopes throughout the site.

Mirabilis froebelii (Behr.) Greene var. *froebelii*. [*M. multiflora* (Torr.) Gray var. *glandulosa*]. Giant Four-O'Clock. Infrequent perennial herb on cinder cones and sandy flats.

Onagraceae - Evening-Primrose Family

Camissonia boothi (Dougl. in Hook.) Raven ssp. *desertorum* (Munz) Raven. Woody Bottle-Waher. Common annual in sandy flats and slopes throughout the site.

Camissonia boothi (Doul. in Hook.) Raven ssp. *inyoensis* (Munz) Raven. Bottle-Washer. Infrequent in sandy areas and on sides of cinder cones.

Camissonia campestris (Greene) Raven. Field Primrose. Very common annual on sandy and coarser flats and slopes.

Camissonia chamaenerioides (Gray) Raven. Willow-Herb-Primrose. Infrequent annual noted only on rocky canyon slopes and sandy bottomlands.

Camissonia claviformis (Torr. & Frem.) Raven ssp. *claviformis*. Clavate-Fruited Primrose. Infrequent annual on sandy slopes and flats.

Camissonia palmeri (Wats.) Raven. Palmer's-Primrose. Infrequent annual on sandy flats.

Camissonia pterosperma (Wats.) Raven. Pygmy-Primrose. Infrequent annual on slopes.

Camissonia pusilla Raven. Dwarf Contorted Camissonia. Very infrequent on gravelly ridges.

Epilobium adenocaulon Hausskn. var. *parishii* (Trel.) Munz. Willow Herb. Rare perennial at Haiwee Spring.

Oenothera primiveris Gray ssp. *bufonis* (Jones) Munz. Yellow Desert Evening Primrose. Infrequent annual on sandy flats.

Oenothera primiveris Gray ssp. *primiveris* Gray. Yellow Desert Evening Primrose. Infrequent annual on sandy flats.

Orobanchaceae - Broom-Rape Family

Orobanche cooperi (Gray) Heller. Broom-Rape. Fleshy root parasite, rare in sandy soil.

Papaveraceae - Poppy Family

Argemone munita Dur. & Hilg. ssp. argentea G. Ownbey. Prickly-Poppy. Infrequent on basaltic slopes.

Argemone munita Dur. & Hilg. ssp. munita. Prickly-Poppy. Infrequent on rocky slopes.

Canbya candida Parry. White Canbya. Rare annual reported by DeDecker south of Red Hill, south of Cinder Road on flats. Listed as rare and not endangered by the California Native Plant Society.

Eschscholzia covillei Greene. Coville Pygmy Poppy. Infrequent annual on sandy to rocky slopes.

Eschscholzia minutiflora Wats. Pygmy Poppy. Common annual throughout site on sandy and coarser soils. Listed as not rare but of limited distribution by the California Native Plant Society.

Platystemon californicus Benth. var. crinitus Greene. Cream-Cups. Rare annual flowering in early spring on lower hills.

Plantaginaceae - Plantain Family

Plantago insularis Eastw. var. fastigiata (Morris) Jeps. Wooly Plantain. Infrequent to frequent annual on rocky slopes and flats.

Plantago purshii R. & S. var. oblonga (Morris) Shinners. Pursh's Plantain. Infrequent annual on sandy and coarser soils.

Polemoniaceae - Phlox Family

Eriastrum eremicum (Jeps.) Mason. Desert Eriastrum. Infrequent annual on sandy soils.

Eriastrum sapphirinum (Eastw.) Mason ssp. ambiguum (Jones) Mason. Sapphire Eriastrum. Frequent annual on sandy flats and slopes.

Eriastrum wilcoxii (A. Nels.) Mason. Wilcox's Eriastrum. Frequent annual on sandy flats and slopes.

Gilia brecciarum Jones. Gilia. Infrequent annual on rocky slopes.

Gilia cana (Jones) Heller ssp. speciosa (Jeps.) A. & V. Grant. Broad-Flowered Gilia. Conspicuous large-flowered infrequent annual, mostly on sandy slopes.

Gilia filiformis Parry ex Gray. Thread-stemmed Gilia. Infrequent annual among rocks on hillsides.

Gilia latiflora (Gray) Gray ssp. cosana A. & V. Grant. Broad-Flowered Gilia. Infrequent annual on sandy and rocky slopes.

Gilia stellata. Heller. Star Gilia. Infrequent annual on rocky slopes.

Gilia latiflora (Gray) Gray ssp. *elongata* A. & V. Grant. Broad-Flowered Gilia. Infrequent annual on rocky slopes and in washes.

Gilia latifolia Wats. Broad-Leaved Gilia. Infrequent usually annual on rocky canyon walls and slopes.

Gilia leptomeria Gray. Tooth-Leaved Gilia. Frequent annual on sandy to coarse slopes.

Gilia micromeria Gray. Gilia. Infrequent annual in sandy soils.

Gilia modocensis Eastw. Modoc Gilia. Infrequent annual on fine to coarse sandy flats.

Gilia ochroleuca Jones ssp. *ochroleuca*. Desert Gilia. Infrequent annual on rocky slopes to sandy flats.

Gilia scopolorum Jones. Rock Gilia. Infrequent annual on rocky slopes and flats.

Gilia sinuata Dougl. ex Benth. Sinuate-Leaved Gilia. Infrequent annual on rocky slopes.

Langloisia matthewsii (Gray) Greene. Desert Calico. Common annual on sandy soils.

Linanthus aureus (Nutt.) Greene. Golden Gilia. Common annual of sandy flats, slopes and in depressions.

Linanthus bigelovii (Gray) Greene. Bigelow's Linanthus. Infrequent annual on sandy slopes.

Linanthus dichotomus Benth. Evening-Snow. Infrequent on sandy slopes and flats.

Linanthus parryae (Gray) Greene. Parry's Linanthus. Frequent on sandy flats and slopes.

Polygonaceae - Buckwheat Family

Chorizanthe brevicornu Torr. ssp. *brevicornu*. Brittle Chorizanthe. Frequent annual on sandy to rocky slopes.

Chorizanthe rigida (Torr.) T. & G. Spiny Chorizanthe. Spinose, frequent annual on sandy flats to rocky slopes.

Chorizanthe thurberi (Gray) Wats. Thurber's Chorizanthe. Frequent annual on fine to coarse sandy flats and slopes.

Chorizanthe watsonii T. & G. Watson's Chorizanthe. Infrequent annual on gravelly flats, slopes.

Eriogonum baileyi Wats. Bailey's Buckwheat. Infrequent annual on slopes.

Eriogonum brachyanthum Cov. Short-Flowered Buckwheat. Frequent annual along roads and on slopes at higher elevations.

Eriogonum deflexum Torr. ssp. baratum (Elmer) Munz. Flat-Crowned Buckwheat. Infrequent annual on sandy to cinder slopes.

Eriogonum deflexum Torr. ssp. deflexum. Flat-Crowned Buckwheat. Infrequent annual with the above subspecies.

Eriogonum fasciculatum Benth. ssp. polifolium (Benth.) Stokes. California Buckwheat. Common shrub mostly on rocky slopes and coarse sandy slopes.

Eriogonum gracillimum Wats. Slender Buckwheat. Infrequent annual on sandy flats.

Eriogonum glandulosum (Nutt.) Nutt. ex Benth. Glandular Buckwheat. Infrequent annual on fine cinder slopes near cinder cones.

Eriogonum inflatum Torr. & Frem. var. inflatum. Desert Trumpet. Common perennial on sandy to coarse soils, from flats to slopes or rocky hillsides, occationally abundant on slopes of cinder cones.

Eriogonum maculatum Heller. Leafy-Stemmed Buckwheat. Common annual on sandy to gravelly flats and slopes.

Eriogonum nidularium Cov. Birds-Nest Buckwheat. Common annual mostly on sandy to coarser soils throughout area.

Eriogonum nudum Dougl. ex Benth. ssp. saxicola (Heller) Munz. Naked-Stemmed Buckwheat. Infrequent perennial herb noted near Haiwee Spring, Devil's Kitchen, and on cinder cones south of Volcano Peak.

Eriogonum pusillum T. & G. Puny Buckwheat. Common delicate annual mostly in sandy soil.

Eriogonum reniforme Torr. & Frem. Kidney-Leaved Buckwheat. Infrequent on sandy flats.

Eriogonum trichopes Torr. Little Trumpet. Frequent annual, becoming locally dominant in depressions and occasionally exposed slopes.

Eriogonum wrightii Torr. ex Benth. ssp. subscaposum (Wats.) Stokes. Wright's Buckwheat. Infrequent subshrub known from vicinity of Devil's Kitchen and Haiwee Spring.

Oxytheca perfoliata T. & G. Perfoliate Oxytheca. Frequent on sandy to coarse slopes throughout area.

Pterostegia drymarioides F. & M. Pterostegia. Infrequent annual on rocky slopes.

Portulacaceae - Purslane Family

Calandrinia ciliata (R. & P.) DC. var. menziesii (Hook.) Macbr. Red Maids. Infrequent in the Coso Hot Springs area.

Calyptridium monandrum Nutt. in T. & G. Common Calyptridium. Frequent fleshy annual in the Coso Hot Springs area, infrequent on sandy slopes.

Calyptridium parryi Gray ssp. nevadense (J.T. Howell) Munz. Parry's Calyptridium. Frequent fleshy annual around Coso Hot Springs area.

Claytonia perfoliata Donn. var. utahensis (Rydb.) Munz. Miner's-Lettuce. Infrequent fleshy annual on shaded canyon slopes.

Ranunculaceae - Crowfoot Family

Delphinium parishii Gray ssp. parishii. Desert Larkspur. Infrequent on sandy slopes.

Ranunculus cymbalaria Pursh var. saximontanus Fern. Infrequent in wet areas among saltgrass south of Little Lake.

Rosaceae - Rose Family

Coleogyne ramosissima Torr. Blackbush. Infrequent shrub on site, noted only on slopes on western border of Rose Valley.

Purshia glandulosa Curran. Antelope Bush. Infrequent shrub on slopes west of Rose Valley.

Rubiaceae - Madder Family

Galium hilendiae Demp. & Ehrend. ssp. hilendiae. Bedstraw. Infrequent subshrub on rocky outcrops and canyon walls.

Galium matthewsii Gray. Matthew's Bedstraw. Infrequent subshrub on rocky outcroppings.

Salicaceae - Willow Family

Populus fremontii Wats. var. fremontii. Western Cottonwood. Infrequent tree at Coso Junction, below Little Lake, at the Lewis Ranch.

Salix lasiandra Benth. var. abramsii. Willow. Frequent tree along seepage at Haiwee Spring.

Salix lasiolepis Benth. var. lasiolepis. Arroyo Willow. Frequent tree along seepage at Haiwee Spring and below Little Lake around ponds.

Saururaceae - Lizard's-tail Family

Anemopsis californica Hook. Yerba Mansa. Common perennial herb in wet areas near Little Lake.

Scrophulariaceae - Figwort Family

Antirrhinum filipes Gray. Twining Snapdragon. Infrequent annual on rocky hillsides twining among shrubs and rocks.

Antirrhinum kingii Wats. King's Snapdragon. Infrequent annual of open sandy slopes and flats.

Castilleja chromosa A. Nels. Desert Paintbrush. Infrequent perennial herb on rocky slopes.

Castilleja *linariaefolia* Benth. Linear-Leaved Paintbrush. Infrequent perennial herb in moist areas.

Cordylanthus *canescens* Gray. [*C.* *maritimus* Nutt. ssp. *c.* Chuang & Heck.]. Alkali Bird's Beak. Rare in wet areas around ponds below Little Lake. (Thorne record).

Mimulus *bigelovii* (Gray) Gray var. *bigelovii*. Bigelow's Monkey-Flower. Infrequent annual on sandy to clayish slopes.

Mimulus *bigelovii* (Gray) Gray var. *cuspidatus* Grant. Bigelow's Monkey-Flower. Frequent annual mostly in sandy flats, slopes, sometimes in fine cinders or clays.

Mimulus *cardinalis* Dougl. ex Benth. Scarlet Monkey-Flower. Locally frequent perennial in wet areas below Haiwee Spring.

Mohavea *breviflora* Cov. Lesser Mohavea. Rare viscid annual on rocky slopes.

Orthocarpus *purpurascens* Benth. var. *ornatus* Jeps. Owl's Clover. Frequent annual on sandy flats and slopes.

Penstemon *incertus* Bdg. Western Desert Penstemon. Rare subshrub in gravelly sand in wash east of Coso Hot Springs.

Scrophularia *desertorum* (Munz) Shaw. Desert Figwort. Infrequent perennial in granitic rocky outcrops along northern border of site.

Solanaceae - Nightshade Family

Datura *meteloides* A. DC. [*D.* *wrightii* Regel.]. Infrequent perennial herb in flats near Little Lake.

Lycium *andersonii* Gray. Anderson's Box-Thron. Common thorny shrub through much of site, particularly in Mixed Desert Scrub.

Lycium *cooperi* Gray. Cooper's Box-Thorn. Frequent throughout site mostly with Mixed Desert Scrub.

Nicotiana *attenuata* Torr. Coyote Tobacco. Rare annual in sandy wash north of Coso Hot Springs.

Nicotiana *trigonophylla* Dunal in A. DC. Desert Tobacco. Infrequent weakly perennial herbs, noted from rocky slopes and in canyons.

Tamaricaceae - Tamarisk Family

**Tamarix* *aphylla* (L.) Karsten. Tamarisk. One tree cultivated along wash north of Coso Hot Springs.

**Tamarix* cf. *parviflora* DC. Tamarisk. Several small trees growing around ponds below Little Lake.

Urticaceae - Nettle Family

Urtica holosericea Nutt. [U. dioica L. ssp. holosericea (Nutt.) Thorne]. Hoary Nettle. Infrequent perennial herb in wet areas below Haiwee Spring.

Vitaceae - Grape Family

Vitis girdiana Munson. Desert Grape. Rare woody vine along seepage below Haiwee Spring.

Zygophyllaceae - Caltrop Family

Larrea tridentata (Sees & Moc. ex DC.) Cov. Creosote Bush. Common shrub, often with aspect dominance on slopes except at higher elevations.

*Tribulus terrestris L. Puncture Vine. Infrequent naturalized annual at Coso Hot Springs.

MONOCOTYLEDONEAE

Agavaceae - Agave Family

Yucca brevifolia Engelm. in Wats. var. brevifolia. Joshua Tree. Common tree mostly in sandy to deeper soils.

Amaryllidaceae - Amaryllis Family

Dichelostemma pulchella (Salisb.) Heller var. pauciflora. Blue Dicks. Infrequent bulbous perennial herb on hillsides and flats.

Muilla coronata Greene. Crowned Muilla. Frequent bulb-bearing perennial herb in clay soils through site.

Muilla maritima (Torr.) Wats. Long-Stemmed Muilla. Infrequent bulb-bearing perennial herb in clay soils.

Cyperaceae - Sedge Family

Carex subfusca W. Boott. Rusty Sedge. Infrequent perennial among saltgrass around and below Little Lake.

Eleocharis parishii Britt. Parish's Spike-Rush. Frequent perennial in wet areas below Haiwee Spring and around and below Little Lake.

Scirpus acutus Muh. Hard-Stem Bulrush. Frequent perennial around Little Lake.

Scirpus americanus Pers. Three-Square. Frequent annual in wet areas around and below Little Lake.

Scirpus olneyi Gray. Three-Square. Frequent annual in wet areas around and below Little Lake.

Scirpus paludosus A. Nels. Bulrush. Rare perennial herb on wet margins of small ponds south of Little Lake (Thorne record).

Juncaceae - Rush Family

Juncus mexicanus Willd. Mexican Rush. Frequent perennial at Haiwee Spring seepage and around and below Little Lake.

Juncus rugulosus Engelm. Wrinkled Rush. Infrequent perennial in moist areas below Haiwee Spring and around Little Lake.

Juncus xiphioides E. Mey. Iris-Leaved Rush. Infrequent perennial in moist areas below Haiwee Spring.

Liliaceae - Lily Family

Calochortus kennedyi Porter. Desert Mariposa. Infrequent bulbiferous perennial herb in higher slopes and flats in Mixed Desert Scrub.

Zigadenus brevibracteatus (Jones) Hall. Desert Zygadene. Infrequent bulbiferous perennial in sandy flats.

Poaceae - Grass Family

*Agrostis stolonifera L. var. major (Gaud.) Farwell. Redtop. Rare naturalized perennial grass in wet areas near Coso Hot Springs.

Aristida glauca (Nees) Walp. Glaucuous three-awn. Infrequent tufted perennial known only from the Devil's Kitchen area.

*Avena sativa L. Cultivated Oats. Rare annual at Coso Junction Rest Stop.

Bouteloua barbata Lag. Six-week Gramma. Infrequent but locally common annual around the Coso Hot Springs area.

*Bromus rubens L. Foxtail Chess. Common naturalized annual occurring throughout area.

*Bromus tectorum L. Cheat Grass. Common naturalized annual occurring throughout the area.

*Bromus trinii Desv. in Gray. Chilean Chess. Frequent naturalized annual on rocky slopes throughout the Mixed Desert Scrub area.

*Cynodon dactylon (L.) Pers. Bermuda Grass. Infrequent naturalized perennial reported near Coso Hot Springs.

Distichlis spicata (L.) Greene var. stricta (Torr.) Beetle. Saltgrass. Very common perennial forming dense fields around and below Little Lake.

Elymus triticoides Buckl. Beardless Wild-rye. Rare perennial at Haiwee Spring.

Festuca octoflora Walt. [Vulpia octoflora (Walt.) Rydb.]. Six-Weeks Fescue. Common diminutive annual throughout site.

Festuca reflexa Buckl. [Vulpia microstachys Nutt. var. pauciflora (Beal) L. & G.]. Few-Flowered Fescue. Infrequent annual in open flats and rocky slopes.

Hilaria jamesii (Torr.) Benth. Galleta. Infrequent perennial grass on upper rocky slopes.

Hordeum leporinum Link. Wild Barley. Rare annual naturalized around Coso Hot Springs.

Melica frutescens Scribn. Tall Melic. Rare perennial on rocky slopes east of Coso Hot Springs.

Melica imperfecta Trin. var. refracta Thurb. in Wats. Small-Flowered Melica. Rare perennial known only from the Haiwee Spring seepage area.

Muhlenbergia asperifolia (Nees. & Mey.) Parodi. Rare perennial grass in saline flats near Little Lake.

Muhlenbergia rigens (Benth.) Hitchc. Deergrass. Rare large tufted perennial in seepage below Haiwee Spring. Occurs also in canyons in adjacent Sierras.

Oryzopsis bloomeri (Bol.) Ricker. [Stiporyzopsis b. (Bol.) B.L. Johnst.]. Hybrid ricegrass. Infrequent perennial on sandy flats in upper valleys. A hybrid between Oryzopsis hymenoides and Stipa speciosa and occurring with both species.

Oryzopsis hymenoides (R. & S.) Ricker. Ricegrass. Common tufted perennial in sandy soil throughout the site.

*Paspalum distichum L. Knotgrass. Rare naturalized perennial in seepage area below Haiwee Spring.

Phragmites australis (Cav.) Trin. ex Steud. Common Reed. Infrequent perennial near Little Lake and near Sykes.

Poa scabrella (Thurb.) Benth. & Vasey. Pine Bluegrass. Frequent tufted perennial mostly on rocky slopes in Mixed Desert Scrub.

*Polypogon monspeliensis (L.) Desf. Beardgrass. Infrequent introduced annual in wet seepage areas below Haiwee Spring and around and below Little Lake.

*Schismus arabicus Nees. Arabian Schismus. Common, naturalized, low tufted annuals throughout site but particularly on light to coarse sandy soils.

*Schismus barbatus (L.) Thell. Mediterranean Schismus. Common, naturalized, low tufted annuals throughout site.

Sitanion hystrix (Nutt.) J.G. Sm. var. hystrix. Bottlebrush Squirreltail. Frequent perennial mostly in Mixed Desert Scrub or with Four-Winged Saltbush.

Spartina gracilis Trin. Desert Cordgrass. Infrequent perennial in wet areas around Little Lake. Listed as very rare and endangered by the California Native Plant Society.

Stipa speciosa Trin. & Rupr. Desert Needlegrass. Common tufted perennial throughout the site on both sandy to rocky soils, becoming more common on steep rocky slopes, particularly on the cinder cones, where it will be occasionally abundant.

Potamogetonaceae - Pondweed Family

Potamogeton latifolius (J.W. Robbins) Morong. Broad-Leaved Pondweed. A submerged aquatic collected at Little Lake.

Potamogeton pectinatus L. Pondweed. Common in Little Lake. A submerged aquatic.

Ruppia maritima L. Ditch-grass. Common in Little Lake and ponds below. (Thorne record).

Typha latifolia L. Cat-tail. Infrequent perennial in ponds below Little Lake.

Zannichelliaceae - Horned Pondweed Family

Zannichellia palustris L. Horned Pondweed. Submerged aquatic in channals between the ponds below Little Lake.

Summary of Flora

	Families	Genera	Species
Native	49	179	361
Naturalized	10	21	24
Total	51	197	385

93.8 percent native species

Exhibit 1

Examiner J. Henrickson
Date Sept 20, 1979

SII

PLANT SPECIES FIELD DATA REPORT

I. Nomenclature

A. Botanical Name Spartina gracilis Trin.

B. BLM Code SPGR C. Family Poaceae D. Common Name Alkali Cordgrass

II. Population Information

A. Location
1. Common Designation Little Lake
2. Quad Name Little Lake Quadrangle
3. Township T 23S
4. Range R 38E
5. Section 8
6. ¼¼ Section NE¼, NW¼, SW¼
7. Latitude
8. Longitude

B. Vegetation Phenology
___ 1. Dormant
___ 2. New growth
___ 3. Full Develop.
___ 4. Senescent
___ 5. Regrowth

C. Flowering and Fruiting Pheonology
___ 1. No Activity
___ 2. Buds Formed
___ 3. Buds Opening
___ 4. Full Flower
___ 5. Immature Fruit
___ 6. Mature Fruit

D. Population Size, Individuals
___ 1. 1 - 50
X 2. 50 - 100
___ 3. 101 - 200
___ 4. > 200

E. Area Occupied, Acres
X 1. < 1
___ 2. 1 - 10
___ 3. 10 - 100
___ 4. > 100

F. Population Trend
___ 1. Increasing
X 2. Stable
___ 3. Decreasing

G. Principle Impacts Observed
X 1. Physical Disturbance Negative
___ 2. Grazing Negative
___ 3. Disease Negative
___ 4. Physical Disturbance Positive
___ 5. Grazing Positive
___ 6. Disease Positive

H. Utilization Observed

UTILIZATION CLASS

	None	Light	Mod.	Heavy	Dead
Cattle					
Sheep					
Burros					
Game					
Rabbits					
Rodents					
Insects					

I. Specimen(s) Collected

Yes X No ___ ID# Henrickson 18254 (Voucher RSA).

J. Specimen(s) Photographed

Yes ___ No ___ ID# ___

K. Unusual Features

III. Habitat Information

A. Topographic Relationship

ca 3160 1. Elevation pln 2. Slope ___ 3. Aspect

B. Substratum
___ 1. Rock
___ 2. Rocky
___ 3. Gravely
___ 4. Sandy
___ 5. Loamy
___ 6. Clay
___ 7. Carbonate
___ 8. Gypsun
___ 9. Alkalie ?
___ 10. Saline
___ 11. Acid
X 12. Other wet area

C. Local Land Form
___ 1. Stream Side
X 2. Seep
___ 3. Dry Wash
___ 4. Steep Slope
___ 5. Talus Slope
___ 6. Upper Fan
___ 7. Lower Fan
___ 8. Plain
___ 9. Playas
___ 10. Sand Dunes
___ 11. Road Side
___ 12. Canyon Bottom
___ 13. Cliffs
___ 14. Cove

D. Soil Moisture ___ 1. Low ___ 2. Medium X 3. High

E. Plant Community
___ 1. Creosote
___ 2. Blackbrush
___ 3. Shadscale
___ 4. Allscale
___ 5. Cheesebush
___ 6. Sagebrush
___ 7. Hoppsage
___ 8. Desert Holly
___ 9. Cactus
___ 10. Yucca
___ 11. Saltgrass
___ 12. Semigrassland
___ 13. Hilaria
___ 14. Dalea-Olynea-Cercidium
___ 15. Juniper-Pinyon
___ 16. Joshuatree
X 17. Other Emergent aquatic freshwater

The only population of this species occurred on the west side of Little Lake in a marshy area ca. 100 m south of the Hunting Club's trailers.

Exhibit 2

SII

Examiner J. Henrickson
Date Sept 20 1979

PLANT SPECIES FIELD DATA REPORT

I. Nomenclature

A. Botanical Name Pholisma arenarium Nutt. ex Hook.

B. BLM Code PHAR C. Family Lennoaceae D. Common Name Pholisma

II. Population Information

A. Location
1. Common Designation Coso Hot Springs
2. Quad Name Haiwee Reservoir Quad
3. Township T22s
4. Range R 39E
5. Section S 3
6. ¼¼ Section NW¼, NW¼
7. Latitude ____
8. Longitude ____

B. Vegetation Phenology
___1. Dormant
___2. New growth
___3. Full Develop.
___4. Senescent
___5. Regrowth

C. Flowering and Fruiting Pheonology
___1. No Activity
___2. Buds Formed
___3. Buds Opening
___4. Full Flower
___5. Immature Fruit
___6. Mature Fruit

D. Population Size, Individuals
X 1. 1 - 50
___2. 50 - 100
___3. 101 - 200
___4. > 200

E. Area Occupied, Acres
X 1. < 1
___2. 1 - 10
___3. 10 - 100
___4. > 100

F. Population Trend
___1. Increasing
X 2. Stable
___3. Decreasing

G. Principle Impacts Observed
___1. Physical Disturbance Negative
___2. Grazing Negative
___3. Disease Negative
___4. Physical Disturbance Positive
X 5. Grazing Positive
___6. Disease Positive

H. Utilization Observed

UTILIZATION CLASS

	None	Light	Mod.	Heavy	Dead
Cattle					
Sheep					
Burros				X	
Game					
Rabbits				X	
Rodents			X		
Insects					

I. Specimen(s) Collected

Yes X No ___ ID# Zembal et al. (Voucher at RSA)

J. Specimen(s) Photographed

Yes ___ No ___ ID# ___

K. Unusual Features

III. Habitat Information

A. Topographic Relationship
3600 ft 1. Elevation
pln 2. Slope
___ 3. Aspect

B. Substratum
___1. Rock
___2. Rocky
___3. Gravely
X 4. Sandy
___5. Loamy
___6. Clay
___7. Carbonate
___8. Gypsun
___9. Alkalie
___10. Saline
___11. Acid
___12. Other

C. Local Land Form
___1. Stream Side
___2. Seep
X 3. Dry Wash
___4. Steep Slope
___5. Talus Slope
___6. Upper Fan
___7. Lower Fan
___8. Plain
___9. Playas
___10. Sand Dunes
___11. Road Side
___12. Canyon Bottom
___13. Cliffs
___14. Cove

D. Soil Moisture X 1. Low ___2. Medium ___3. High

E. Plant Community
X 1. Creosote
___2. Blackbrush
___3. Shadscale
___4. Allscale
___5. Cheesebush
___6. Sagebrush
___7. Hoppsage
___8. Desert Holly
___9. Cactus
___10. Yucca
___11. Saltgrass
___12. Semigrassland
___13. Hilaria
___14. Dalea-Olynea-Cercidium
___15. Juniper-Pinyon
___16. Joshuatree
___17. Other broad sandy wash

The only population of this species from the CGSA was located by Zembal *et al.* (1978b) in the vicinity of Coso Hot Springs 140 meters east of the lone tamarisk tree just north of the main Hot Springs facilities. "The plants were growing in sandy soil, in close association with Cheesebush (*Hymenoclea salsola* var. *salsola*), the host plant..."

Exhibit 3

SII

Examiner J. Henrickson
Date Sept 20 1979

PLANT SPECIES FIELD DATA REPORT

I. Nomenclature

A. Botanical Name Canbya candida Parry

B. BLM Code CACA
C. Family Papaveraceae
D. Common Name White Canbya

II. Population Information

A. Location
1. Common Designation South of Red Hill
2. Quad Name Little Lake Quad.
3. Township T 22S
4. Range R 37E
5. Section S 31
6. ¼¼ Section SW¼, SE¼
7. Latitude
8. Longitude

B. Vegetation Phenology
☐ 1. Dormant
☐ 2. New growth
☐ 3. Full Develop.
☐ 4. Senescent
☐ 5. Regrowth

C. Flowering and Fruiting Pheonology
☐ 1. No Activity
☐ 2. Buds Formed
☐ 3. Buds Opening
☐ 4. Full Flower
☐ 5. Immature Fruit
☐ 6. Mature Fruit

D. Population Size, Individuals
☐ 1. 1 - 50
☒ 2. 50 - 100
☐ 3. 101 - 200
☐ 4. > 200

E. Area Occupied, Acres
☒ 1. < 1
☐ 2. 1 - 10
☐ 3. 10 - 100
☐ 4. > 100

F. Population Trend
☐ 1. Increasing
☒ 2. Stable
☐ 3. Decreasing

G. Principle Impacts Observed
☐ 1. Physical Disturbance Negative
☐ 2. Grazing Negative
☐ 3. Disease Negative
☐ 4. Physical Disturbance Positive
☒ 5. Grazing Positive
☐ 6. Disease Positive

H. Utilization Observed

UTILIZATION CLASS

	None	Light	Mod.	Heavy	Dead
Cattle			C		
Sheep					
Burros					
Game					
Rabbits					
Rodents					
Insects					

I. Specimen(s) Collected

Yes X No ID# DeDecker Collection number unknown

J. Specimen(s) Photographed

Yes No ID#

K. Unusual Features

III. Habitat Information

A. Topographic Relationship
vs 3350 1. Elevation
pln 2. Slope
3. Aspect

B. Substratum
☐ 1. Rock
☐ 2. Rocky
☐ 3. Gravely
☒ 4. Sandy
☐ 5. Loamy
☐ 6. Clay
☐ 7. Carbonate
☐ 8. Gypsun
☐ 9. Alkalie
☐ 10. Saline
☐ 11. Acid
☐ 12. Other

C. Local Land Form
☐ 1. Stream Side
☐ 2. Seep
☐ 3. Dry Wash
☐ 4. Steep Slope
☐ 5. Talus Slope
☐ 6. Upper Fan
☐ 7. Lower Fan
☐ 8. Plain
☐ 9. Playas
☐ 10. Sand Dunes
☐ 11. Road Side
☐ 12. Canyon Bottom
☐ 13. Cliffs
☐ 14. Cove

D. Soil Moisture ☒ 1. Low ☐ 2. Medium ☐ 3. High

E. Plant Community
☐ 1. Creosote
☐ 2. Blackbrush
☐ 3. Shadscale
☒ 4. Allscale
☐ 5. Cheesebush
☐ 6. Sagebrush
☐ 7. Hoppsage
☐ 8. Desert Holly
☐ 9. Cactus
☐ 10. Yucca
☐ 11. Saltgrass
☐ 12. Semigrassland
☐ 13. Hilaria
☐ 14. Dalea-Olynea-Cercidium
☐ 15. Juniper-Pinyon
☐ 16. Joshuatree
☐ 17. Other

The only population of this annual species was found south of Cinder Road, south of Red Hill in cindery-sandy flats among Atriplex polycarpa. It may be expected elsewhere in the CGSA.

REFERENCES

Abrams, L. 1940, 1960. Illustrated flora of the Pacific States. 4 vols. Stanford Univ. Press. Stanford, CA.

Adams, S., B. R. Strain, and M. S. Adams. 1970. Water-repellent soils, fire and annual plant cover in a desert scrub community of southeastern California. Ecology 51:696-700.

Anderson, D. J. 1971. Pattern in desert perennials. J. Ecol. 59:555-560.

Bamberg, S. A., A. Wallace, G. Kleinkopf, and A. Vollmer. 1973. Plant productivity and nutrient interrelationships of perennials in the Mojave Desert. P 1-52. In I.B.P. Desert Biome report. R.M. 73-10.

Bamberg, S. A., G. E. Kleinkopf, A. Wallace, and A. Vollmer. 1975. Comparative photosynthetic production of Mojave Desert shrubs. Ecology 56-732-736.

Barbour, M. G. 1967. Ecoclinal patterns in the physiological ecology of a desert shrub Larrea divaricata. Ph.D. Dissert. Duke Univ., Durham, NC. 242 pp.

-----. 1968. Germination requirements of the desert shrub Larrea divaricata. Ecology 49:915-923.

-----. 1969. Age and space distribution on the desert shrub Larrea divaricata. Ecology 50:679-685.

Barbour, M.G., G. Cunningham, W. C. Oechel, and S. A. Bamberg. 1977. Growth and development, form and function. p. 48-91. In T. J. Mabry, J. H. Hunziker and D. R. Difeo, Jr. Creosote Bush: Biology and Chemistry of Larrea in New World Deserts. Dowden, Hutchinson and Ross, Stroudsburg, PA. 284 pp.

Barbour, M. G., and J. Major. 1977. Terrestrial vegetation of California. John Wiley & Sons, New York. 1002 pp.

Beatley, J. C. 1967. Survival of winter annuals in the northern Mojave Desert. Ecology 48:745-750.

-----. 1969. Biomass of desert winter annual plant populations in southern Nevada. Oikos 20:261-273.

-----. 1974. Effects of rainfall and temperature on the distribution and behavior of Larrea tridentata (creosote bush) in the Mojave Desert of Nevada. Ecology 55:245-261.

-----. 1975. Climates and vegetation pattern across the Mojave Great Basin Desert transition of Southern Nevada. Amer. Midland Natur. 93(1): 53-70.

-----. 1976. Vascular plants of the Nevada Test Site and central-southern Nevada: ecologic and geographic distributions. Nat. Tech. Inform. Cent., Springfield, VA. 308 pp.

-----. 1976b. Rainfall and fluctuating plant populations in relation to distributions and numbers on desert rodents in southern Nevada. Oecologia 24: 21-42.

Billings, W. D. 1951. Vegetation zonation in the Great Basin of Western North America in Les bases ecologiques de la régénération de le végétation des zones arides. Internat. Coloq. Internat. Union Biol. Sci. Ser. B, 9: 101-122.

Bradley, W. G. 1970. The vegetation of Saratoga Springs, Death Valley National Monument. Southwest Natur. 15: 111-129.

Bradley, W. G. and J. R. Deacon. 1967. The biotic communities of southern Nevada. p. 201-295. In Pleistocene studies in southern Nevada. Wormington, H. M. and D. Ellis (eds). Nev. State Mus. Anthro. pop. No. 13.

Burk, J. H. 1977. Sonoran Desert. p. 869-889. In M. G. Barbour and J. Major. Terrestrial vegetation of California. John Wiley & Sons, NY.

Chaetham, N. H., and J. R. Haller. 1975. University of California Natural Land and Water Reserves System. The NLWRS Checklist of California Habitat Types. Review Draft. (Unpubl. copy). 65 pp.

Christensen, E. M. 1959. A comparative study of the climates of mountain brush pinyon-juniper, and sagebrush communities in Utah. Proc. Utah, Acad-Sci. 36:174-175.

Christensen, E. M., and H. B. Johnson. 1964. Presettlements vegetation and vegetational changes in three valleys in central Utah. Brigham Young Univ. Sci. Bull.Biol. Ser. 4:1-16.

Clokey, I. W. 1951. Flora on the Charleston Mountains, Clark County, Nevada. Univ. Calif. Press. Berkeley. 274 pp.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, and J. L. Reveal. 1972. Intermountain flora: vascular plants of the intermountain west, U.S.A. Vol 1. Hafner, NY. 270 pp.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren. 1977. Intermountain flora: vascular plants on the intermountain west, U.S.A. Vol 6. Columbia Univ. Press, NY. 584 pp.

Davidson, E. and M. Fox. 1974. Effects of off-road motorcycle activity on the Mojave Desert vegetation and soil. Madroño 22:381-390.

Evans, R. A., H. R. Holbo, R. E. Eckert, Jr., and J. A. Young. 1970. Influences on weed control and seedling methods on the functional environment of rangelands. Weed Sci. 18:154-162.

Fennemann, N. M. 1931. Physiography of Western United States. McGraw-Hill Book Co., Inc. NY. 534 pp.

Frenkel, R. E. 1970. Ruderal vegetation along some California roadsides. Univ. of Cal. Pub. Geogr. 20:1-163.

Gleason, H. A. 1926. The individualistic concept of the plant association. Bull. Torrey Bot. Club. 53:7-26.

-----. 1939. The individualistic concept of the plant association. Amer. Midl. Natur. 22:92-110.

Griffin, J. R., and W. B. Critchfield. 1972. The distribution of forest trees in California. USDA Forest Serv. Res. Paper. PSW-82/1972. 114 pp.

Harris, G. A. 1967. Some competitive relationships between Agropyron spicatum and Bromus tectorum. Ecol. Monogr. 37:89-111.

Hitchcock, C. L., A. Cronquist, M. Ownbey, J. W. Thompson. 1964. Vascular plants of the pacific northwest. Vol 2. Univ. of Washington Press, Seattle, WA.

Hunt, D. B. 1966. Plant ecology of Death Valley, California. Geol. Survey Prof. Paper 509. Washington, D.C.

Hunziker, H. H., R. A. Palacios, L. Poggio, C. A. Naranjo and T. W. Young. Geographic distribution, morphology, hybridization, cytogenetics and evolution. P 10-47. In T. J. Mabry, J. H. Hunziker, D. R. Difeo, Jr. Creosote bush: Biology and Chemistry of Larrea in new world deserts. Dowden, Hutchinson & Ross. Stroudsburg, PA.

Jaeger, E. C., and A. C. Smith. 1966. Introduction to the natural history of southern California. Univ. Calif. Press. Berkeley, CA. 104 pp.

Johnson, H. B. 1975. Gas exchange strategies in desert plants, pp. 105-120. In D. M. Gates and R. B. Schmerl (eds.). Perspectives in Biophysical Ecology. Springer-Verlag, NY.

-----. 1976. Vegetation and plant communities of southern California deserts--a functional view. pp. 125-164. In J. Latting (ed.). Plant communities of southern California. Calif. Native Plant Soc., Spec. Pub. No. 2. Berkeley.

Johnson, H. B., F. C. Vosek, and T. Yonkers. 1975. Productivity, diversity and stability relationships in Mojave Desert roadside vegetation. Bull. Torrey Bot. Club. 102:106-115.

King, T. J., and S. R. J. Woodell. 1973. The causes of regular patterns in desert perennials. J. Ecol. 61:761-765.

Knipe, D. and C. H. Herbel. 1966. Germination and growth of some semi desert grassland species treated with aqueous extract from creosote bush. Ecology 47:775-781.

Kornoelje, T. A. 1973. Plant communities of the Covington flats area. Joshua Tree National Monument. M. A. Thesis. Calif. State Univ., Long Beach.

Lunt, O. R., J. Lety, and S. B. Clark. 1973. Oxygen requirements for root growth in three species of desert shrubs. Ecology 54: 1356-1362.

Mabry, T. J., J. H. Hunziker, D. R. Difeo, Jr. Creosote Bush: Biology and chemistry of Larrea in new world deserts. Dowden, Hutchinson & Ross, Stroudsburg, PA. 284 pp.

Marks, J. B. 1950. Vegetation and soil relations in the lower Colorado Desert. Ecology 31: 176-193.

McKelvey, S. D. 1938. Yuccas of the southwestern United States. Part 1. Arnold Arboretum of Harvard University, Jamaica Plain, MA. 150 pp.

Muller, C. H. 1940. Plant succession in the Larrea - Flourensia climax. Ecology 21: 206-212.

-----. 1953. The association of desert annuals with shrubs. Amer. J. Bot. 40: 53-60.

Muller, W. H., and C. H. Muller. 1956. Association patterns involving desert plants that contain toxic products. Amer. J. Bot. 43:354-361.

Munz, P. A. 1974. A flora of southern California. Univ. of Calif. Press. 1086 pp.

Munz, P. A., and D. D. Keck. 1959. A California flora. Univ. Calif. Press. Bereley. 1681 pp.

Ornduff, R. 1974. Introduction to California plant life. Univ. Calif. Press. Berkeley. 152 pp.

Prigge, B. A. 1975. Flora of the Clark Mountain Range, San Bernardino County California. M.S. Thesis, Calif. State Univ., L.A. 64 pp.

Powell, W. R. (ed.). 1974. Inventory of rare and endangered vascular plants of California. Cal. Native Plant Soc., Spec. Publ. No. 1. 56 pp.

Randall, D. C. 1972. An analysis of some desert shrub vegetation of Saline Valley, California. Ph.D. Dissert. Univ. of Calif., Davis. 186 pp.

Robertson, J.H. 1943. Seasonal root development of sagebrush Artemisia tridentata Nutt. in relation to range reseeding. Ecology 24:125-126.

Rowlands, D. G. 1978. The vegetation dynamics of Joshua Tree (Yucca brevifolia Engelm.) in the southwestern United States of America. Ph.D. Dissert. Univ. Calif., Riverside. 192 pp.

Sankary, M. N., and M. G. Barbour. 1972. Autecology of Atriplex polycarpa from California. Ecology 53:1155-1162.

Shantz, H. L., and R. L. Piemeisel. 1924. Indicator significance of the natural vegetation of the southwestern desert region. J. Agric. Res. 28:721-801.

Sheps, L. O. 1973. Survival of Larrea tridentata (S & M) seedlings in Death Valley National Monument, California. Israel J. Bot. 22:8-15.

Shreve, F. 1942. The desert vegetation of North America. Bot. Review 8: 195-246.

Simpson, P. G. 1975. The anatomy and morphology of the Joshua Tree (Yucca brevifolia): on arborescent monocot. Ph.D. Dissert., Univ. Calif., Santa Barbara. 524 pp.

Stebbins, R. C. 1974. Off-road vehicles and the fragile desert. Amer. Biol. Teacher 36:203-208, 294-304.

Sternberg, L. 1976. Growth forms of Larrea tridentata. Madrono 23:408-417.

Tidestrom, I. 1925. Flora of Utah and Nevada. Contr. U.S. Nat. Herb. Vol 25.

Ting, I. P., H. B. Johnson, and S. R. Szarek. 1972. Net CO_2 fixation in crassulaceon metabolism plants. In net carbon dioxide assimilation in higher plants. C. C. Black (ed.). Southern Sect of the American Society of Plant Physiology and Cotton Inc.

Thorne, R. F. 1976. The vascular plant communities of California. pp. 1-31. In J. Latting (ed.), Plant Communities of Southern California, Calif. Native Plant Soc., Spec. Pub. 2.

-----. (in press). The desert and other transmontone plant communities of southern California. (unpubl. MS. 26 pp.) (To be published by the Southern California Botanists.)

Twisselmann, E. C. 1967. A flora of Kern County, California. Wasmann J. Biol. 25:1-395.

Vasek, F. C. 1973. On the growth rate of a Joshua tree. Madroño 22:30.

Vasek, F. C., H. B. Johnson, and D. H. Eslinger. 1975a. Effects of pipeline construction on creosote scrub vegetation of the Mojave Desert. Madrono 23(1): 1-13.

Vasek, F. C., H. B. Johnson, and G. D. Brum. 1975b. Effects of powerline transmission lines on vegeation of the Mojave Desert. Madrono 23:114-130.

Vasek, F. C., and M. G. Barbour. 1977. Mojave Desert scrub vegetation. pp. 835-867. In M. G. Barbour & J. Major (eds.) Terrestrial Vegetation of California. John Wiley & Sons. NY.

Vasek, F. C., and R. F. Thorne. 1977. Transmontone coniferous vegetation. pp. 797-832. In M. G. Barbour and J. Major (eds.). Terrestrial Vegetation of California. John Wiley & Sons. NY.

Wallace, A., and E. M. Romney. 1972. Radioecology and ecophysiology of desert plants at the Nevada Test Site. U.S. Atomic Energy Commission T.I.D.-25954. 439 pp.

Wallace, A., V. Q. Hale, G. E. Kleinkopf, and R. C. Huffaker. 1971. Carboxydismutase and phosphoenolpyruviate carboxylase activities from leaves of some plant species from the northern Mojave and southern Great Basin Deserts. Ecology 52:1093-1095.

Wells, P. V., and L. M. Shields. 1964. Distribution of *Larrea divaricata* in relation to a temperature inversion at Yucca flat, southern Nevada. Southwest. Nat. 9:51-55.

Went, F. W. 1948. Ecology of desert plants I. Observations on germination in the Joshua Tree National Monument, California. Ecology 29:242-253.

-----. 1955. The ecology of desert plants. Sci. Amer. 192:68-75.

Woodell, S. R. J., H. A. Mooney, and A. J. Hill. 1969. The behavior of *Larrea divaricata* (creosote bush) in response to rainfall in California. J. Ecol. 57:37-44.

Young, J. A., R. A. Evans and J. Major. 1977. Sagebush steppe. pp. 763-796. In M. G. Barbour and J. Major (eds.) Terrestrial Vegetation of California. John Wiley and Sons, NY.

Zembal, R. L., B. W. Massey, and T. E. LaRocque. 1978a. Winter season bird population studies in the Coso Geothermal Area of Inyo County California. Report to USDI, BLM. Bakersfield Office.

Zembal, R., C. Gall, D. Kruska and P. Lobnitz. 1978b. An inventory of the vascular plants and small mammals of the Coso Hot springs Area of Inyo County, California. Report to Dept. of Navy, Naval Weapons Center, China Lake, CA.

Randall, D. C. 1972. An analysis of some desert shrub vegetation of Saline Valley, California. Ph.D. Dissert. Univ. of Calif., Davis. 186 pp.

Robertson, J.H. 1943. Seasonal root development of sagebrush *Artemisia tridentata* Nutt. in relation to range reseeding. Ecology 24:125-126.

Rowlands, D. G. 1978. The vegetation dynamics of Joshua Tree (*Yucca brevifolia* Engelm.) in the southwestern United States of America. Ph.D. Dissert. Univ. Calif., Riverside. 192 pp.

Sankary, M. N., and M. G. Barbour. 1972. Autecology of *Atriplex polycarpa* from California. Ecology 53:1155-1162.

Shantz, H. L., and R. L. Piemeisel. 1924. Indicator significance of the natural vegetation of the southwestern desert region. J. Agric. Res. 28:721-801.

Sheps, L. O. 1973. Survival of *Larrea tridentata* (S & M) seedlings in Death Valley National Monument, California. Israel J. Bot. 22:8-15.

Shreve, F. 1942. The desert vegetation of North America. Bot. Review 8: 195-246.

Simpson, P. G. 1975. The anatomy and morphology of the Joshua Tree (*Yucca brevifolia*): on arborescent monocot. Ph.D. Dissert., Univ. Calif., Santa Barbara. 524 pp.

Stebbins, R. C. 1974. Off-road vehicles and the fragile desert. Amer. Biol. Teacher 36:203-208, 294-304.

Sternberg, L. 1976. Growth forms of *Larrea tridentata*. Madrono 23:408-417.

Tidestrom, I. 1925. Flora of Utah and Nevada. Contr. U.S. Nat. Herb. Vol 25.

Ting, I. P., H. B. Johnson, and S. R. Szarek. 1972. Net CO_2 fixation in crassulaceon metabolism plants. In net carbon dioxide assimilation in higher plants. C. C. Black (ed.). Southern Sect of the American Society of Plant Physiology and Cotton Inc.

Thorne, R. F. 1976. The vascular plant communities of California. pp. 1-31. In J. Latting (ed.), Plant Communities of Southern California, Calif. Native Plant Soc., Spec. Pub. 2.

-----. (in press). The desert and other transmontone plant communities of southern California. (unpubl. MS. 26 pp.) (To be published by the Southern California Botanists.)

Twisselmann, E. C. 1967. A flora of Kern County, California. Wasmann J. Biol. 25:1-395.

Vasek, F. C. 1973. On the growth rate of a Joshua tree. Madroño 22:30.

Vasek, F. C., H. B. Johnson, and D. H. Eslinger. 1975a. Effects of pipeline construction on creosote scrub vegetation of the Mojave Desert. Madrono 23(1): 1-13.

Vasek, F. C., H. B. Johnson, and G. D. Brum. 1975b. Effects of powerline transmission lines on vegeation of the Mojave Desert. Madrono 23:114-130.

Vasek, F. C., and M. G. Barbour. 1977. Mojave Desert scrub vegetation. pp. 835-867. In M. G. Barbour & J. Major (eds.) Terrestrial Vegetation of California. John Wiley & Sons. NY.

Vasek, F. C., and R. F. Thorne. 1977. Transmontone coniferous vegetation. pp. 797-832. In M. G. Barbour and J. Major (eds.). Terrestrial Vegetation of California. John Wiley & Sons. NY.

Wallace, A., and E. M. Romney. 1972. Radioecology and ecophysiology of desert plants at the Nevada Test Site. U.S. Atomic Energy Commission T.I.D.-25954. 439 pp.

Wallace, A., V. Q. Hale, G. E. Kleinkopf, and R. C. Huffaker. 1971. Carboxydismutase and phosphoenolpyruviate carboxylase activities from leaves of some plant species from the northern Mojave and southern Great Basin Deserts. Ecology 52:1093-1095.

Wells, P. V., and L. M. Shields. 1964. Distribution of Larrea divaricata in relation to a temperature inversion at Yucca flat, southern Nevada. Southwest. Nat. 9:51-55.

Went, F. W. 1948. Ecology of desert plants I. Observations on germination in the Joshua Tree National Monument, California. Ecology 29:242-253.

-----. 1955. The ecology of desert plants. Sci. Amer. 192:68-75.

Woodell, S. R. J., H. A. Mooney, and A. J. Hill. 1969. The behavior of Larrea divaricata (creosote bush) in response to rainfall in California. J. Ecol. 57:37-44.

Young, J. A., R. A. Evans and J. Major. 1977. Sagebush steppe. pp. 763-796. In M. G. Barbour and J. Major (eds.) Terrestrial Vegetation of California. John Wiley and Sons, NY.

Zembal, R. L., B. W. Massey, and T. E. LaRocque. 1978a. Winter season bird population studies in the Coso Geothermal Area of Inyo County California. Report to USDI, BLM. Bakersfield Office.

Zembal, R., C. Gall, D. Kruska and P. Lobnitz. 1978b. An inventory of the vascular plants and small mammals of the Coso Hot springs Area of Inyo County, California. Report to Dept. of Navy, Naval Weapons Center, China Lake, CA.

GPO 694-688/149

Form 1279—3
(June 1984)

BORROWER'S CAR

TD 195 .E4 C67 1980 su

Field ecology technic
report on the Coso

DATE LOANED	BORROWER

USDI — BLM